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7

operation & maintenance

3208 Truck Engine

40S1-UP 32Y1-UP 2Z1-UP 51Z1-UP

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IMPORTANT SAFETY INFORMATION

Most accidents involving engine operation and maintenance are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs.

Read and understand all safety precautions and warnings before operating or performing lubrication and maintenance on this engine.

Basic safety precautions are outlined in the "Safety" section of this guide and in the description of operations where hazards exist. WARNING labels have also been put on the engine to provide instructions and to identify specific hazards which if not heeded could cause bodily injury or death to you or other persons. These warnings in the guide and on the engine labels are identified by the symbol

Operations that may cause only engine damage are identified by NOTICE labels on the engine and in the guide.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this guide and on the engine are therefore not all inclusive. If a procedure, tool or work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the engine will not be damaged or made unsafe by the method of operation or maintenance procedures you choose.

⚠ WARNING

Improper operation, lubrication or maintenance of this engine can be dangerous and could result in injury or death.

Do not operate this engine until you read and understand the instructions in the "Operation" section of the Operation and Maintenance Guide or the Owner's Manual.

Do not perform any lubrication and maintenance on this engine until you read and understand the instructions in the "Maintenance" section of the Operation and Maintenance Guide or the Owner's Manual.

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Table of Contents

Emergency Service 2
Foreword 3
Safety 4
Model Views 7
General Information 8
Serial Number and Information Plate Location 8

Operation Section

Gauges 9
Before Starting the Engine 11
Starting the Engine 13
Operating the Engine 15
Stopping the Engine 16

Maintenance Section

Maintenance Recommendations 16
Coolant, Fuel and Lubricant Specifications 19
Oil and Filter Change Interval (Mileage) 21
Refill Capacities 22
Oil and Filter Change Interval Chart (Service Hours of Engine Operation) 22
Recommended Lubricant Viscosities 22
Lubrication and Maintenance Chart 23
Daily 24
First Oil Change Interval Only 29
Oil and Filter Change Interval 30
Every 1200 Service Hours or 1 Year or _____ km (_____ Miles), Whichever Occurs First 40
Every 2400 Service Hours or Two Years or _____ km (_____ Miles), Whichever Occurs First 46
Troubleshooting 53
Emission Related Components 67
Important Reference Numbers 71

Emergency Service (U.S.A. Only)

When a problem arises concerning the sale, operation or service of your engine, it will normally be handled by the distributor or dealer in your area. The service facility nearest you can be located twenty-four hours a day by calling the appropriate phone number listed below.

In U.S. (except Illinois, Alaska, Hawaii) 800/447-4986.
In the State of Illinois 309/673-3252 (collect).

Your satisfaction is a primary concern to Caterpillar, its distributors and their dealers. To assure your complete satisfaction, we suggest the following steps be followed should you have a problem that has not been handled to your satisfaction.

Step One

Discuss your problem with a member of management from the distributorship or dealership. If your problem originates with a dealer, explain the matter to a management member of the distributorship with whom the dealer has his parts and service agreement.

Step Two

When it appears that your problem cannot be readily resolved at the distributor level without additional assistance, use the above telephone numbers and ask to talk to someone at Caterpillar's Engine Division Service Department.

Step Three

If you are still not satisfied, present the engine matter in writing to:

Caterpillar Tractor Co.
Manager, Truck Engine Business
Peoria, Illinois 61629

When contacting Caterpillar's Engine Division Service Department, please keep in mind that ultimately your problem will likely be resolved at the distributorship or dealership using their facilities, equipment, and personnel. Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

Foreword

This guide contains operation instructions and lubrication and maintenance information.

The operation section is a reference for the new operator and a refresher for the experienced one. Read — study — and keep it handy.

Illustrations guide the operator through correct procedures of checking, starting, operating and stopping the engine.

Operating techniques outlined in this publication are basic. Skill and techniques develop as the operator gains knowledge of the engine.

The maintenance section is a guide to equipment care. The illustrated, step-by-step instructions are grouped by servicing intervals. Items in the "Lubrication and Maintenance Chart" are referenced to the detailed instructions that follow.

The Lubrication and Maintenance items are organized for a Preventive Maintenance Program, they are identified by PM-1, PM-2 and PM-3.

If the Preventive Maintenance Program is followed, a periodic tune-up is not required.

Use the service hour meter (if equipped) to determine servicing intervals. Mileage intervals may be used instead of service hour meter intervals if they provide more convenient servicing schedules and approximate the indicated service hour meter reading.

Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in the "Lubrication and Maintenance Chart" may be necessary.

Some photographs in this publication show details or attachments that may be different from your engine. Some photographs show guards or covers removed for clear illustration, that need not be removed for routine lubrication and maintenance.

Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this publication.

Whenever a question arises regarding your engine or this publication, please consult your Caterpillar dealer for the latest available information.

Safety

General

Read and understand all warning plates, decals and notice information before operating, performing maintenance or repairing this engine. Follow service instructions carefully.

Attach a "DO NOT OPERATE" or similar warning tag to the start switch or controls before servicing or repairing the truck engine. These tags, Form SEHS7332, are available from your Caterpillar dealer.

Perform all maintenance unless otherwise specified as follows:

The engine stopped.
The brakes applied.
The protective locks or controls in the applied position.

Wear a hard hat, protective glasses and other protective equipment as required by job conditions.

Do not wear loose clothing or jewelry that can catch on controls or other parts of the engine.

Make certain all protective guards and covers are secured in place on the engine.

Disconnect the batteries before servicing the electrical system.

Do not allow unauthorized personnel in the truck when it is being serviced.

Use the proper tools. Replace or repair broken or damaged equipment.

Do not attempt repairs you do not understand.

Operate the engine only in a well ventilated area.

When operating the engine in a closed area, vent the exhuast to the outside.

Remove all tools, electrical cords and other loose items from the engine before starting.

When starting an engine after repair, make provisions to stop the engine or shutting off air supply, in case there is an overspeed on start-up.

If the engine is not running, do not release the emergency or parking brake systems unless the truck is blocked or restrained.

When using pressure air for cleaning, wear a protective face shield and protective clothing.

Never put maintenance fluids into glass containers.

Crushing or Cutting Prevention

Never attempt adjustments while the truck is moving or the engine is running unless otherwise specified.

Stay clear of all rotating and moving parts.

Keep objects away from moving fan blades. They will throw or cut any object or tool that falls or is pushed into them.

Wear protective glasses when striking a retainer pin to avoid injury to your eyes.

Chips or other debris can fly off objects when struck. Make sure no one can be injured by flying debris before striking any object.

Burn Prevention

At operating temperature, the engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot water or steam. Any contact can cause severe burns.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to remove with your bare hand.

Remove the cooling system filler cap slowly to relieve pressure.

Cooling system conditioner contains alkali. Avoid contact with the skin and eyes and do not drink, to prevent personal injury.

Allow cooling system components to cool before draining.

Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.

Relieve all pressure in air, oil, fuel or cooling systems before any lines, fittings or related items are disconnected or removed.

Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes.

Fire or Explosion Prevention

All fuels, most lubricants and some coolant mixtures are flammable.

Do not smoke while refueling or in a refueling area.

Do not smoke in areas where batteries are charged, or where flammable materials are stored.

If the truck is equipped with an emergency starting receptacle, use a jumper cable with a plug that will mate with the receptacle.

When starting from an external source, always connect the positive (+) boost cable to the positive (+) terminal of the battery of the engine to be started.

Attach the negative (−) boost ground cable last, away from the battery. See the "Operation" section of this guide for specific instructions.

Clean and tighten all electrical connections. Check daily for loose or frayed electrical wires. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.

Keep all fuels and lubricants stored in properly marked containers and away from all unauthorized persons.

Store all oily rags or other flammable material in a protective container, in a safe place.

Do not weld or flame cut on pipes or tubes that contain flammable fluids.

Clean them thoroughly with nonflammable solvent before welding or flame cutting on them.

Remove all flammable materials such as fuel, oil and other debris before they accumulate on the engine.

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses.

Safety

Inspect all lines, tubes and hoses carefully. Do not use your bare hand to check for leaks. Tighten all connections to the recommended torque.

Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires.

Radiators must be kept clean and free from trash to prevent possible overheating.

Debris, dirt and foreign material must not be allowed to accumulate around, on the engine or in the engine compartment, as overheating or a fire could result.

Make sure that all clamps, guards and heat shields are installed correctly to prevent vibration, rubbing against other parts and excessive heat during operation.

Shields, which protect hot exhaust components from oil or fuel spray in the event of a line, tube or seal failure, must be installed correctly.

Ether is flammable. Do not smoke while changing ether cylinders.

Use ether only in well ventilated areas.

Keep ether cylinders out of the reach of unauthorized persons.

Do not store replacement ether cylinders in living areas or in the operator's compartment.

Do not store ether cylinders in direct sunlight. Discard cylinders in a safe place. Do not puncture or burn cylinders.

Fire Extinguisher

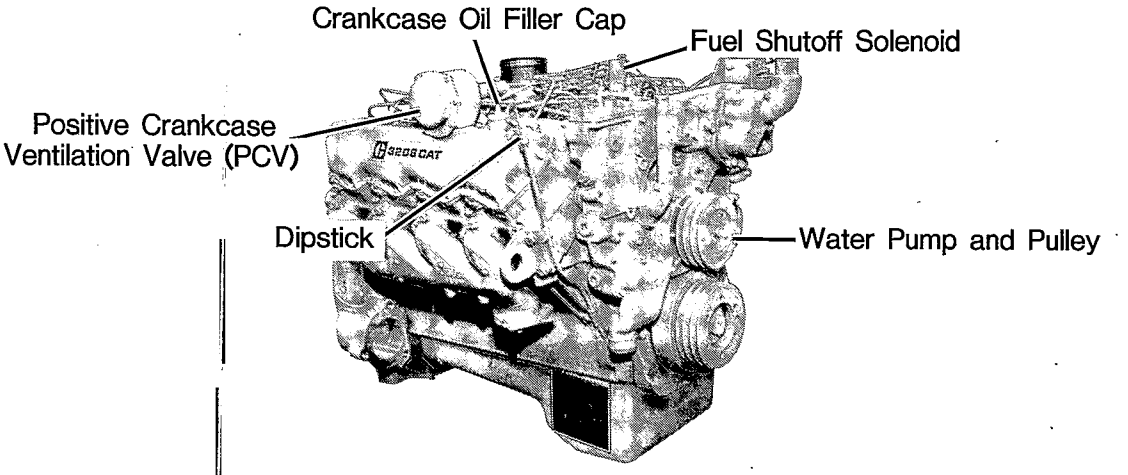
Always have a fire extinguisher on the engine and know how to use it. Inspect and have it serviced as recommended on its instruction plate.

Mounting and Dismounting

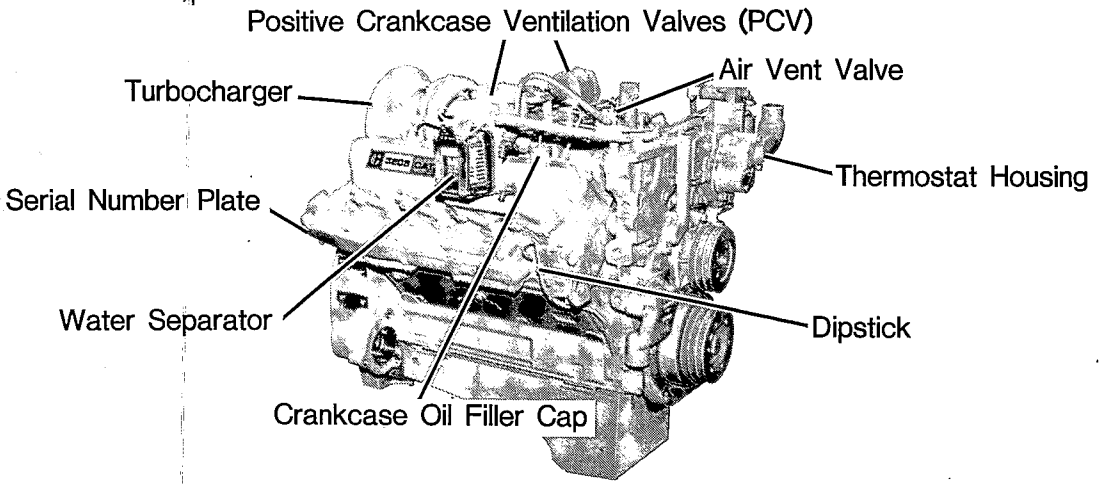
Clean steps, handholds and areas of the truck you will be working on or around.

Do not jump off the truck. Always use steps and handholds when mounting and dismounting. Never work under a partially tilted cab unless it is properly secured.

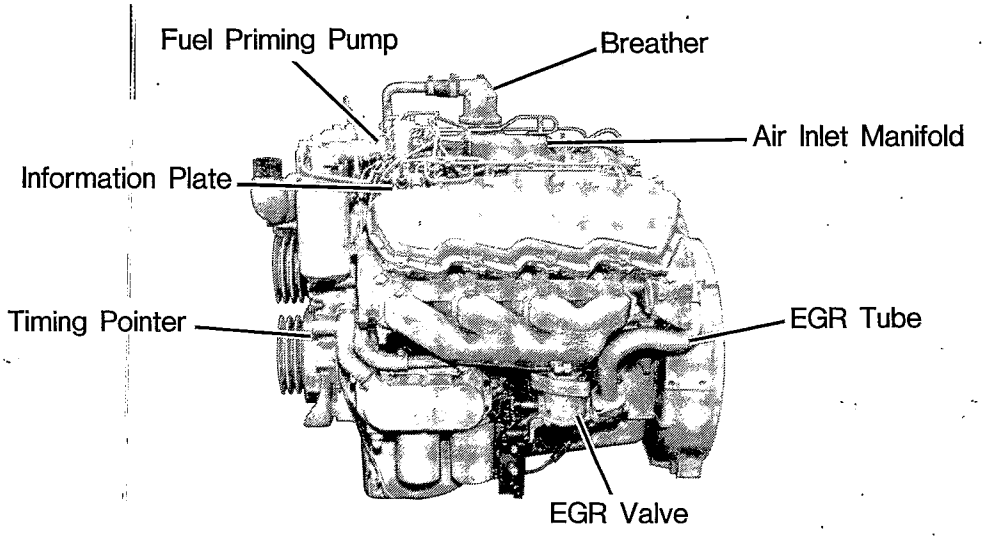
Model Views



3208 Naturally Aspirated Engine



3208 Turbocharged Engine



3208 Engine with Low Emission System (L.E.S.)

General Information

The Caterpillar 3208 Truck Engine is a 10.4 liters (636 cu. in.) displacement, 114 mm (4.5 in.) bore, 127 mm (5.0 in.) stroke, four stroke cycle, 8 cylinder 90° Vee design engine. The firing order is 1-2-7-3-4-5-6-8 and the direction of rotation is counterclockwise, as viewed from the flywheel. The engine can either be naturally aspirated, turbocharged or turbocharged aftercooled, with direct fuel injection.

A mechanical governor controls the fuel injection pump output to maintain the engine rpm selected by the operator.

Individual injection pumps, one for each cylinder, meter and pump fuel under high pressure to an injection valve for each cylinder.

The cooling system consists of a belt driven centrifugal pump, with two thermostats which regulate engine coolant temperature, an oil cooler and a radiator incorporating a shunt system.

The engine lubricating oil is supplied by a gear-type pump, which is both cooled and filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine parts when oil viscosity is high, or if either the oil cooler or the oil filter elements should become clogged.

Efficiency of emission controls and engine performance depends on adherence to proper operation and maintenance recommendations, and use of recommended fuels and lubrication oils.

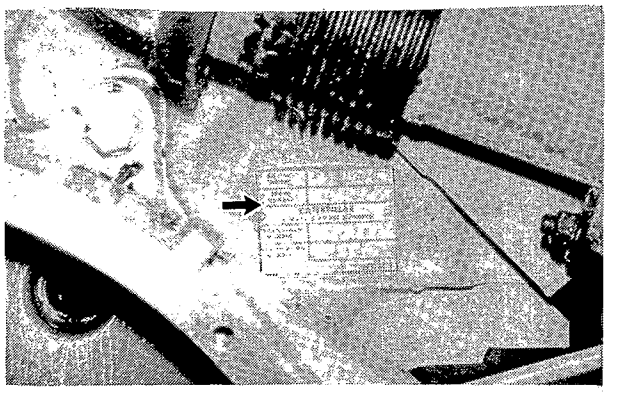
Follow the recommended maintenance schedule with special emphasis on emission related components.

For Engines Used in California

Low Emission System (L.E.S.) Caterpillar 3208 Truck Engines with exhaust gas recirculation. These engines are equipped with an exhaust gas recirculation valve, which on engine start-up, directs some of the exhaust gases to the inlet manifold to be burned again. At full load there is no exhaust gas recirculation.

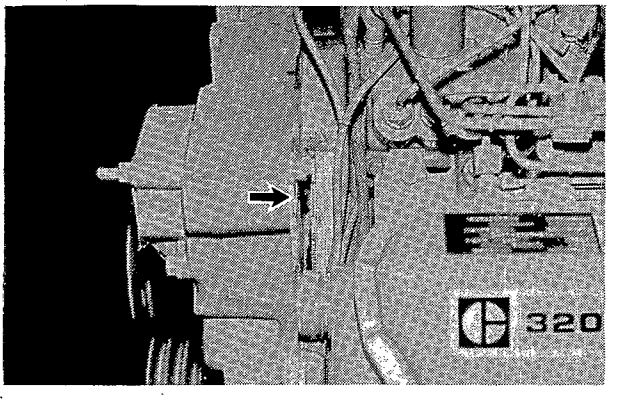
Serial Number and Information Plate Location

Serial Number Plate (Earlier Engines)



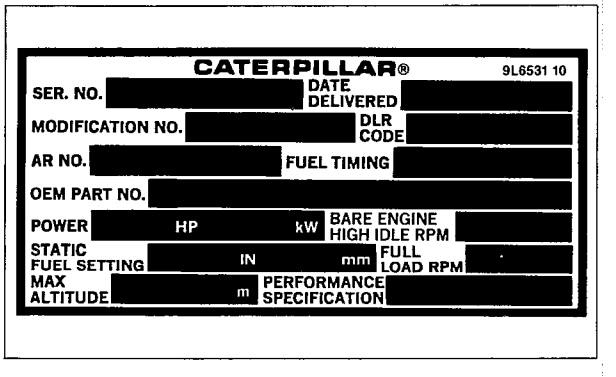
Located on the right rear side of the cylinder block.

Serial Number Plate (Later Engines)



Located on the left front side of the cylinder block.

Information Plate

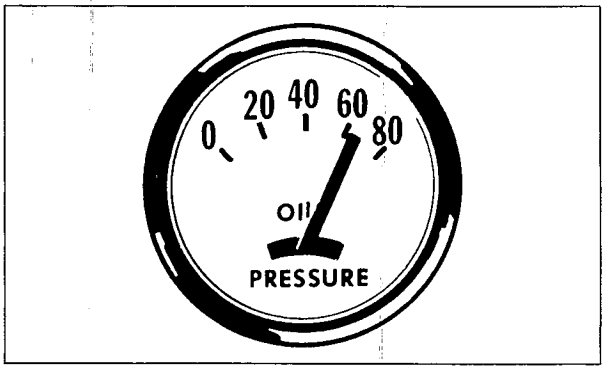


Located on the left valve cover. should the water pump be replaced.

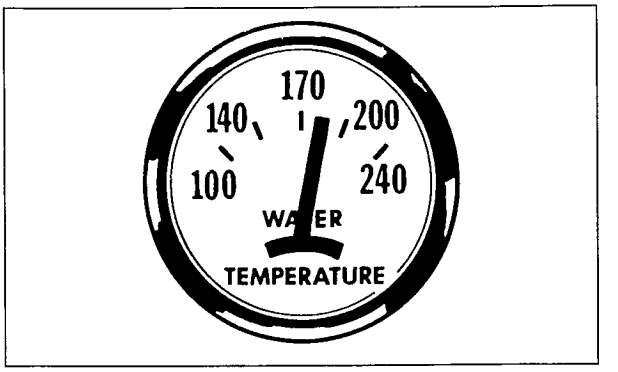
Gauges

Your truck may not have the same or all of the gauges as shown in the illustrations. The illustrations shown are of typical gauges.

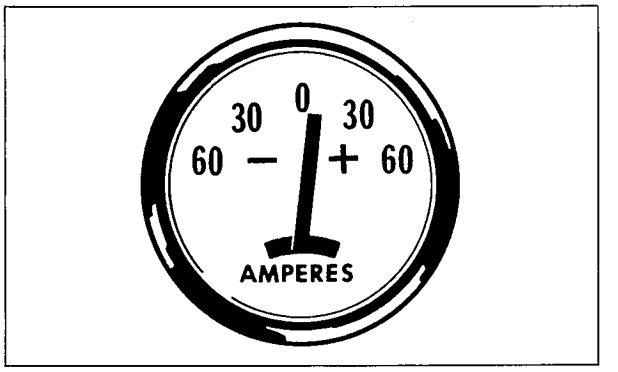
Gauges provide a "look" inside the engine. Be sure they are in good working order. You can determine what is "normal" operating range by observing the gauges over a period of time. The cause of any sudden or significant change in the readings should be determined and corrected.



Oil Pressure — Indicates engine oil pressure. The oil pressure should be between 240 and 480 kPa (35 and 70 psi) when the engine is running at rated engine speed, with SAE10W/30 oil, at operating temperature. A lower pressure is normal at low idling speed. If no pressure is indicated, stop the engine.



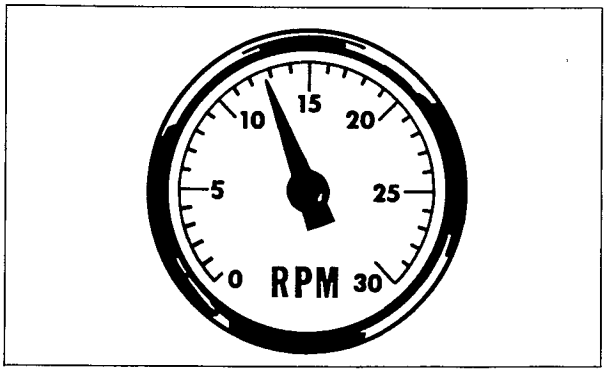
Water Temperature — Indicates engine coolant temperature. It should normally indicate between 71°C (160°F) and 93°C (200°F). Somewhat higher temperatures may occur under certain conditions. Maximum allowable temperature is 99°C (210°F) with the cooling system pressurized.



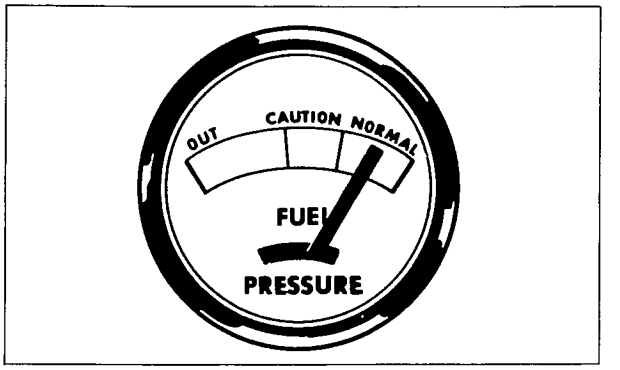
Ammeter — Indicates the amount of charge or discharge in the battery charging circuit. Normal operation of the indicator should be slightly to the positive (right) side of "0" (zero).

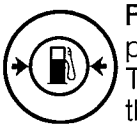
With the engine running, during normal operation, if the indicator is constantly to the negative (left) side of "0" (zero) or shows excessive charge, have the charging system checked for malfunction.

Gauges

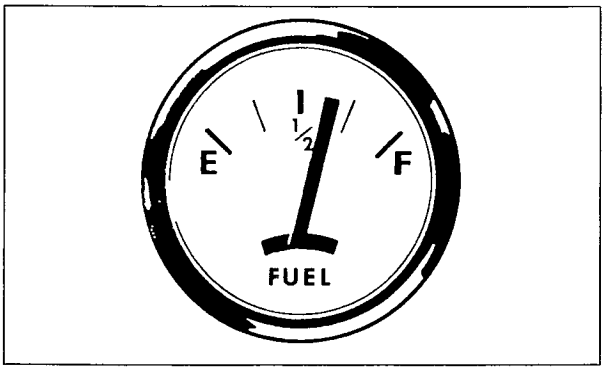


Tachometer — Indicates engine rpm (speed). The engine can be operated between rated speed and high idle without damage, but should not be allowed to overspeed (such as when going downhill).

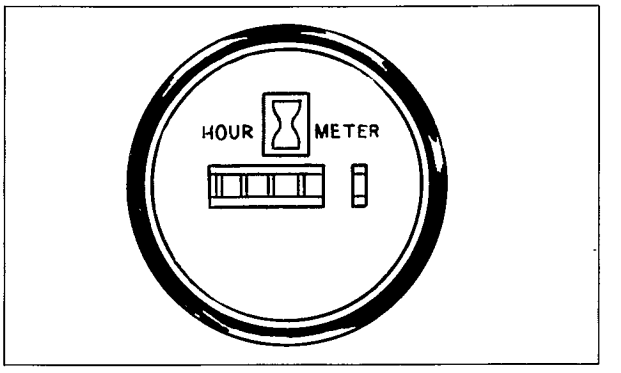




Fuel Pressure — Indicates fuel pressure to the injection pump. The indicator should register in the NORMAL (green) range. When the filter element becomes clogged the indicator will move to the OUT position.



Fuel Level — Indicates fuel level in the fuel tank. Electrically operated, it registers only when the key switch is ON.

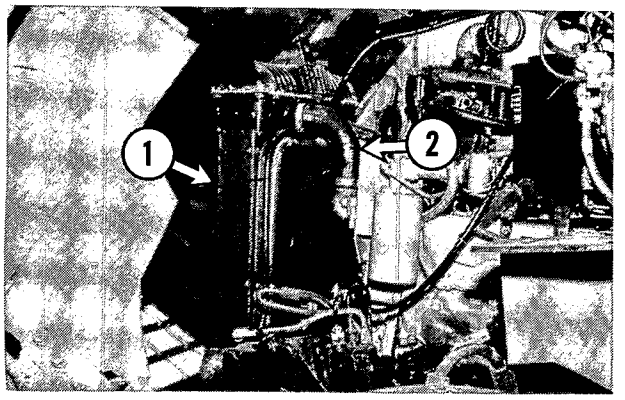


Service Hour Meter — Indicates the total number of hours the engine has operated.

Before Starting the Engine

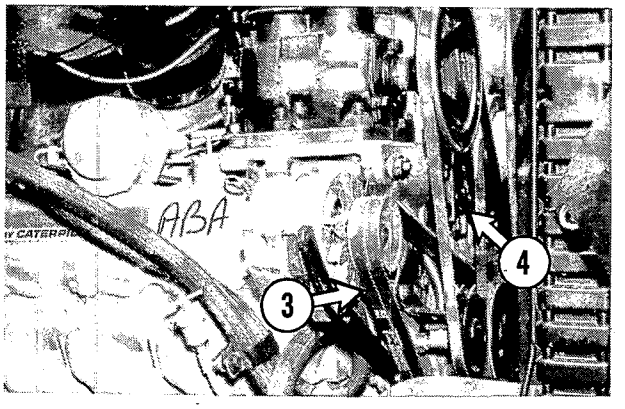
Under the Hood Inspection

For maximum service life of your truck engine, make a thorough under the hood inspection before starting the engine. Look for such items as oil or coolant leaks, loose bolts, worn fan belts and trash buildup. Remove trash buildup and have repairs made as needed.



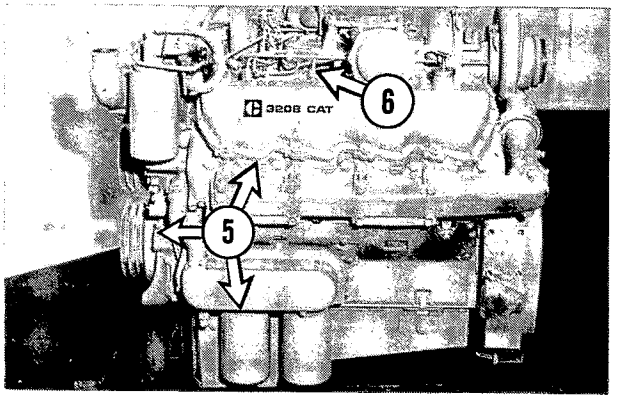
1. Inspect the radiator for leaks and trash buildup.

2. Inspect the radiator and PCV hoses for cracks and loose clamps.



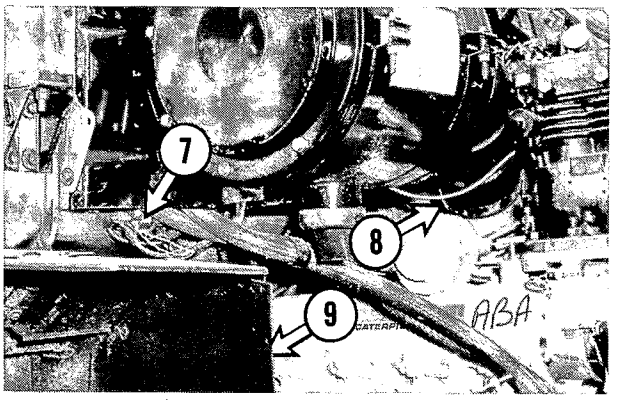
3. Inspect the fan, water pump and accessory drive belts for cracks, breaks and frayed edges. Belts for multiple groove pulleys are sold in matched sets.

4. Inspect the water pump for leaks. Slight evidence of coolant from the drain hole is normal.



5. Inspect the engine for oil leaks, such as front and rear seals, crankcase, oil filters and valve covers.

6. Inspect the fuel system for leaks, loose fuel line clamps and fittings and loose or worn hoses.



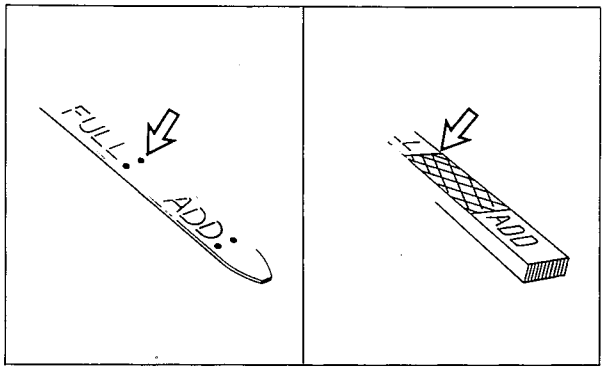
7. Inspect wiring for loose connections and worn or frayed wires.

8. Inspect air intake system hoses and elbows for cracks and loose clamps.

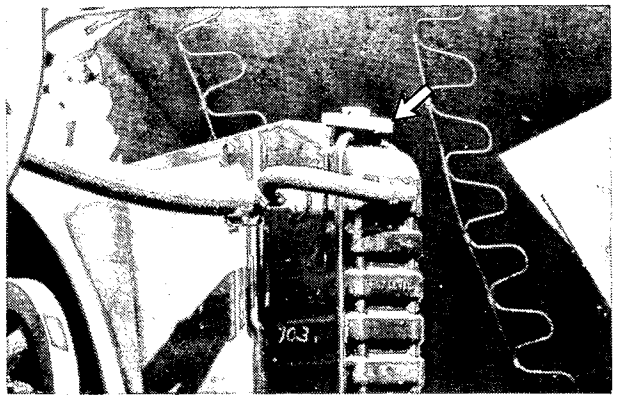
9. Inspect engine-to-frame ground strap for good connection and condition.

Before Starting the Engine

Pre-Start Checks



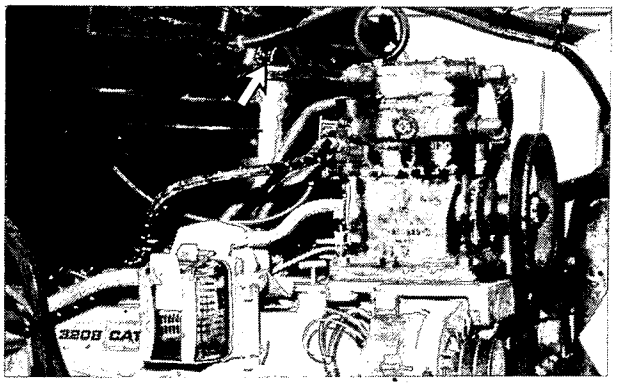
1. Measure the crankcase oil level. The correct oil level is shown by the marks just below the words FULL and ADD on the dipstick. Two dots are currently used to indicate the correct level. Some earlier dipsticks have a line across the dipstick in the same location. Keep the oil level between these marks. Never use the words themselves, to measure the oil level.



2. Check the coolant level with the engine stopped and cold. Remove the radiator cap slowly to relieve pressure.

3. Maintain the coolant level to within 13 mm (1/2 inch) of the bottom of the fill pipe. Install the radiator cap.

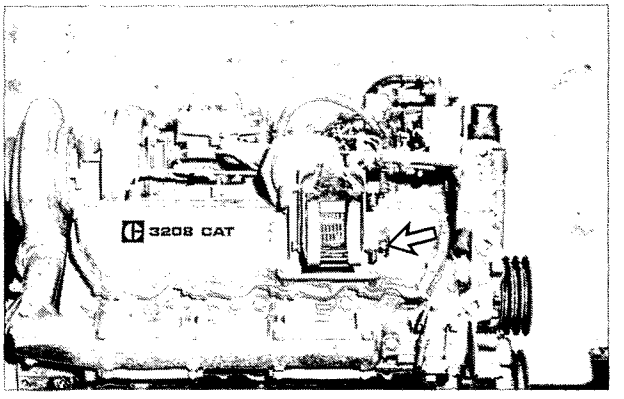
4. If equipped with a sight glass, maintain the coolant to the proper level.



5. Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone or the red piston locks in the visible position.

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.



6. Drain water from the water separator.

Starting the Engine

Above −12°C (10°F)

Caterpillar 3208 Truck Engines are designed to start at temperatures above −12°C (10°F) without using starting aids. If the temperature is below −12°C (10°F), a starting aid may be necessary and/or cylinder block coolant heater may be needed or crankcase oil may need to be heated.

1. Place the transmission controls in NEUTRAL and disengage the flywheel clutch, if so equipped.

2. Push down on the accelerator pedal to the floor once and then release to low idle position.

3. Turn the starter switch to the START position. If the engine fails to start within 30 seconds, release the starter switch and wait 2 minutes to allow the starter motor to cool before using it again.

4. As soon as the engine starts, release the starter switch and reduce engine rpm to low idle.

5. Do not apply load to the engine or increase engine rpm until the oil pressure gauge indicates normal.

6. Operate the engine at low load and low rpm until the coolant temperature is 66°C (150°F) or higher. Check all gauges during the warmup period.

Below −12°C (10°F)

⚠ WARNING

Use starting fluid sparingly and spray it only while cranking the engine. Follow manufacturer's instructions carefully.

Do not store starting fluid containers in the cab.

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1. Follow steps 1 and 2 for "Above −12°C (10°F)."

2. Turn the starter switch to the START position.

NOTICE

Excessive ether can cause piston and ring damage. Use ether for cold starting purposes only.

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3. Spray starting fluid into the precleaner for one second while cranking the engine. Wait at least two seconds before spraying starting fluid again.

4. Release the starter switch when the engine starts and reduce engine rpm to low idle.

5. Operate the engine at low load and low rpm until the coolant temperature is 66°C (150°F) or higher. Check all gauges during the warmup period.

Starting the Engine

Starting With Boost Cables

⚠ WARNING

Batteries give off flammable fumes that can explode.

Prevent sparks near the batteries. They could cause vapors to explode. Do not allow battery cable ends to contact each other or the engine.

Do not smoke when observing the battery electrolyte levels.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

Always wear protective glasses when working with batteries.

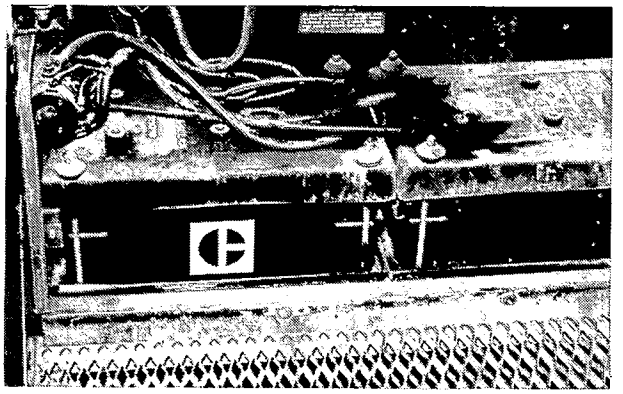
NOTICE

Your engine may have a 12 or 24 Volt starting system. Use only the same voltage for boost starting. The use of a higher voltage will damage the low emission system.

Always connect the boost cables in parallel with the truck battery cables, NEGATIVE (−) to NEGATIVE (−) and POSITIVE (+) to POSITIVE (+).

Do not reverse the battery cables. The alternator can be damaged.

Attach ground cable last and remove first.



1. Fasten the positive (+) clamp of the boost cable to the positive (+) post of the battery.

2. Fasten the negative (−) clamp of the boost cable to the truck frame away from and below the battery.

3. Start the engine.

4. After the engine starts, disconnect the negative (−) cable from the truck frame.

5. Disconnect the positive (+) cable from the battery.

Operating the Engine

Proper operation and maintenance are key factors in obtaining the maximum life and economy of Caterpillar truck engines. Following the directions in this guide will lower operating costs.

1. After normal oil pressure is reached, operate the engine at low load until the temperature gauge begins to move before operating at full load.

2. Select the lowest gear for a smooth, easy, start without slipping the clutch. Avoid jerky starts which put unnecessary stress on the drive train.

3. Use progressive shifting to reduce fuel consumption. Progressive shifting is using only the rpm required to make an upshift into the next gear. The amount of rpm required to make an upshift increases as the truck speed increases or if upshifts are made on upgrades. Experience with your truck will show you how much rpm is required to make upshifts under various conditions.

4. When the desired speed is reached, if the truck can be operated in more than one gear, select the gear that allows the lowest rpm (the highest gear) that will pull the load.

NOTE: Caterpillar manufactures both turbocharged and naturally aspirated (non-turbocharged) 3208 engines. The operating requirements of each are different.

The turbocharged engines may be operated at full load, at any rpm between rated engine speed and 1400 rpm.

The naturally aspirated engines can be operated at full load down to 1900 rpm and may be operated for short periods at full load down to 1400 rpm. Operation at full load below 1400 rpm is not recommended. However, 3208 engines may be operated below 1400 rpm at light loads and low truck speeds. In fact, operation below 1400 rpm at light loads is recommended to achieve the best fuel economy, using the progressive shifting technique.

Upgrade Operation

1. Upgrade operation varies between turbocharged and naturally aspirated engine, due to the differences in minimum rpm, where full load operation is recommended. (See NOTE above).

2. Truck performance on upgrades is normally improved by eliminating unnecessary shifting on either turbocharged or naturally aspirated engines. Turbocharged engines will operate at full load at a lower rpm and require less shifting than naturally aspirated engines.

Downgrade Operation

NOTICE

Do NOT allow the engine rpm to exceed the maximum rated rpm of the engine.

1. On a downgrade, do not coast or put the transmission in neutral.

2. Select the correct gear that does not allow the engine rpm to go more than 200 rpm above rated speed.

3. A simple rule to follow is to select the same gear that would be required to go up the grade.

Stopping the Engine

Before stopping the engine when the engine is operated at low loads, the engine needs to run at low idle about 30 seconds before it is stopped. But, if the engine is operated at highway speeds where the engine was operated at high loads, the engine should be run at low idle for 3 minutes to reduce and stabilize internal engine temperature.

To stop the engine, use the method listed that applies to the shutoff system on your truck.

1. Turn the key switch to the OFF position, or . . .

2. . . . pull OUT the manual shutoff control, or . . .

3. . . . push IN and hold the stop button until the engine stops, then release the button.

Make sure the shutoff procedure is understood. Refer to the truck manufacturer's instructions for your type of engine shutoff system used.

Maintenance Recommendations

Cooling System

NOTICE

Never add coolant to an overheated engine; allow the engine to cool first.

Check the specific gravity of the antifreeze solution frequently in cold weather to ensure adequate protection.

If the engine is to be stored in, or shipped to, an area with below freezing temperatures; the cooling system must be protected against freezing to the lowest expected outside temperature.

All water is corrosive at engine operating temperature. The cooling system should be protected with conditioner at all times regardless of the concentration of antifreeze. This can be done by either using Caterpillar coolant conditioner elements, or by maintaining a 3% to 6% concentration of liquid Caterpillar cooling system conditioner, or equivalent.

To prevent over inhibiting the cooling system, never use both liquid cooling system conditioner and coolant conditioner elements at the same time.

Do not use Caterpillar cooling system conditioner or coolant conditioner elements with Dowtherm 209 Full-Fill coolant. Follow the instructions provided with the Dowtherm 209 Full-Fill coolant.

Cooling System Conditioner Liquid

Maintain a 3% to 6% concentration of liquid Caterpillar cooling system conditioner, or equivalent. Add the correct amount of cooling system conditioner at every oil change interval. Use 0.24 liters (1/2 pint) conditioner per 38 liters (10 U.S. gallons) of cooling system capacity. On new, rebuilt or remanufactured engines and when changing coolant, use 0.95 liters (1 quart) of conditioner per 30 liters (8 U.S. gallons) of cooling system capacity.

Coolant Conditioner Elements

For engines equipped with coolant conditioner elements, install a new maintenance element at every oil change interval. Use a precharge element only when filling the system on new, rebuilt or remanufactured engines, or changing coolant. Your Caterpillar dealer can provide you with the correct coolant conditioner element.

General

Coolant should be drained and replaced every 2400 service hours or 2 year, when Caterpillar cooling system conditioner, or equivalent, is added, as recommended.

Premix antifreeze solution to provide protection to the lowest expected outside temperature. Pure undiluted antifreeze will freeze at −23°C (−10°F).

A mixture of 50% ethylene glycol and 50% water will protect the coolant from freezing down to a temperature of −37°C (−34°F).

Use clean water that is low in scale forming mineral. Do not use softened water.

Filling at over 20 liters (5 U.S. gallons) per minute can cause air pockets in the cooling system.

After draining and refilling the cooling system, start and operate the engine with the fill cap off until the coolant level stabilizes. Add coolant as necessary to fill the system.

Operate with a thermostat in the cooling system year-round. Overheating will occur without a thermostat.

Fuel System

NOTICE

Fill the fuel tank at the end of each day of operation to drive out moist air and to prevent condensation. Do not fill the tank to the top. The fuel expands as it gets warm and may overflow.

Do not fill the fuel filters with fuel before installing them. Contaminated fuel will cause accelerated wear to the fuel system parts.

After changing the fuel filters, bleed the fuel system to remove air bubbles from the system.

Drain water and sediment from the water separator daily and the fuel storage tank weekly, and before the tank is refilled. This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

Use only fuel as recommended in the "Coolant, Fuel and Lubricant Specifications" section of this guide.

Air Intake System

Service the engine air cleaner at regular intervals as determined by the truck manufacturer's recommendations and dust conditions.

An air cleaner service indicator may be mounted on the dash panel or in the engine compartment. A colored piston showing in the window indicates the need for servicing the air cleaner. Replace the filter element at least once a year.

Inspect the air intake system hoses, elbows and gaskets for cracks or damage, replace as needed. Check for loose clamps, tighten as needed.

Check the precleaner (if equipped) daily for accumulation of dust and debris.

Maintenance Recommendations

Scheduled Oil Sampling (S-O-S)

Use Scheduled Oil Sampling (S-O-S) to monitor the condition and maintenance requirements of your equipment. Each oil sample should be taken when the oil is hot and well mixed, to ensure that the sample is representative of the oil in the compartment.

Consult your Caterpillar dealer for complete information and assistance in establishing a S-O-S program for your equipment.

Electrical System

Caterpillar 3208 Truck Engines installed in trucks without an engine-to-frame ground strap can be damaged by electrical discharge.

To prevent electrical discharge damage, check to make sure the truck's electrical system has an engine-to-frame ground strap. For trucks which have the alternator connected to an engine component, the ground strap must connect that component to the frame.

NOTICE

Some vehicles have starter-to-frame ground straps. But, many of these starters are not electrically grounded to the engine. They have internal electrical insulation systems. For this reason, the starter-to-frame ground strap may not be an acceptable ground. Use a separate engine-to-frame ground strap.

When boost starting the engine, follow the instructions in the "Operation Section."

Your engine may have a 12 or 24 Volt starting system. Use only the same voltage for boost starting. The use of a higher voltage or a welder will damage the electrical system and the low emission system (L.E.S.).

General

Follow a scheduled preventive maintenance program.

NOTICE

Accumulated grease and oil on the engine is a fire hazard.

Remove the grease, oil and debris at least every 1000 hours and each time any significant quantity of oil is spilled on the engine.

Coolant, Fuel and Lubricant Specifications

Coolant Specifications

NOTICE

Use a mixture of water, antifreeze and cooling system conditioner. Pure, undiluted antifreeze will freeze at -23°C (-10°F).

Always add cooling system conditioner to water, or install a coolant conditioner element (if equipped). Never use water only.

To prevent over inhibiting the cooling system, never use both liquid cooling system conditioner and a coolant conditioner element (if equipped) at the same time.

Do not use Caterpillar cooling system conditioner or coolant conditioner elements with Dowtherm 209 Full-Fill coolant. Follow the instructions provided with the Dowtherm 209 Full-Fill coolant.

Refer to "Know Your Cooling System," Form SEBD0518, for more detailed specifications and instructions on water and cooling system conditioner sampling and testing.

Water

Acceptable water for use in the ethylene glycol-type antifreeze and water mixture is shown in the chart below:

Acceptable Water		
Water Content	**50% Antifreeze 50% Water**	**Without Antifreeze**
Chlorides	100 ppm or less	50 ppm or less
Sulfates	100 ppm or less	50 ppm or less
Hardness as $CaCo_3$	200 ppm or less	100 ppm or less
Dissolved Solids	500 ppm or less	250 ppm or less
pH	6.5 or higher	6.5 or higher

ppm = parts per million

Antifreeze

Use ethylene glycol-type antifreeze. Use the correct amount, mixed with water, to provide freeze protection to the lowest expected outside temperature.

Cooling System Conditioner (Liquid)

Use Caterpillar cooling system conditioner or equivalent. Add the correct amount of cooling system conditioner at every oil change interval to maintain a 3% to 6% concentration. Conditioner can be purchased from your Caterpillar dealer.

Coolant Conditioner Elements (If Equipped)

Coolant conditioner elements should be used to maintain a 3% to 6% concentration of conditioner. Install a new maintenance element at every oil change interval. Use a precharge element when filling the complete system or changing coolant. Your Caterpillar dealer can provide you with the correct coolant conditioner element.

Fuel Specifications and Information

Types of Fuel

Caterpillar diesel engines have the ability to burn a wide variety of fuels. These fuels are divided into two general groups, preferred and permissible.

The preferred fuels provide maximum engine service life and performance. They are distillate fuels. They are commonly called diesel fuel, furnace oil, gas oil or kerosene.

The permissible fuels are crude oils or blended fuels. Use of these fuels can result in higher maintenance costs and reduced engine service life.

Coolant, Fuel and Lubricant Specifications

Refer to "Fuels for Caterpillar Diesel Engines," Form SEHS7067, for a detailed summary of preferred and permissible fuels and their specifications.

Refer to S.A.E. J313 Diesel Fuels for information about better quality fuels, such as ignition quality, gravity/density, viscosity, cloud point, sulfur content, etc.

Fuel Sulfur Content

The percentage of sulfur in the fuel will affect the engine oil recommendations. If the fuel has over 0.5% sulfur content, the CD/SE or CD/SF engine oil must have a TBN of 20 times the percentage of fuel sulfur (TBN as measured by the ASTM D-2896 method).

Fuel sulfur is chemically changed during combustion to form sulfuric acids. The acid chemically attacks metal surfaces and causes corrosive wear. Higher engine oil TBN values are essential to minimize corrosive wear.

Periodically request fuel sulfur content information from your fuel supplier. Fuel sulfur content can change with each bulk delivery.

Fuel Cetane Requirement

The minimum fuel cetane number recommended for the direct injection engine is 40.

Fuel Cloud Point

Fuel waxing can plug the fuel filters in cold weather. The fuel cloud point must be below the temperature of the surrounding air to prevent filter waxing and power loss. Fuel heating attachments are available from your Caterpillar dealer to minimize fuel filter waxing.

Lubricant Specifications

The abbreviations listed below follow S.A.E. J754 nomenclature. The classifications follow S.A.E. J183 classifications. The MIL specifications are U.S.A. Military Specifications. These definitions will be of assistance in purchasing lubricants. The recommended oil viscosities are found on the "Recommended Lubricant Viscosities" chart.

The prefix "SPC" is a general abbreviation used by Caterpillar to identify special oils such as synthetics or semi-synthetic oils.

Engine Oils

Use oils that meet the Engine Service Classification CD/SE or CD/SF (MIL-L-2104D) or CC/SE or CC/SF (MIL-L-46152B).

Consult the "EMA Lubricating Oils Data Book," Form SEBU5939, for a listing of CD/SE, CD/SF, CC/SE and CC/SF oil brands.

The percentage of sulfur in the fuel will affect the engine oil recommendations. If the fuel has over 0.5% sulfur content, the CD/SE or CD/SF engine oil must have a TBN of 20 times the percentage of fuel sulfur (TBN as measured by the ASTM D-2896 method).

Higher TBN values are essential to retard the corrosive damage to metal engine parts.

Your oil supplier should be able to furnish the correct oils.

Lubricating Grease (MPG)

Use Multipurpose-type Grease (MPG). Multipurpose-type grease which contains 3% to 5% molybdenum disulfide (MPGM) is preferred. NLGI No. 2 Grade is suitable for most temperatures. Use NLGI No. 1 or No. 0 Grade for extremely low temperatures.

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Oil and Filter Change Interval (Mileage)

Mileage and Kilometer Conversion Chart

The recommended oil and filter change interval in service hours of engine operation, the API classification of oil used and the crankcase capacity are given in the "Oil and Filter Change Interval Chart."

The oil and filter change interval, as noted in the "Lubrication and Maintenance Chart," may be too long when a truck is not equipped with an engine service hour meter and the odometer mileage is used for determining the change interval. Examples of this type of application are concrete mixers, garbage packers and fire trucks.

To use mileage as a change interval, calculate the number of miles the truck travels per week or month and divide this figure by the number of hours the engine operates per week or month. This answer will give you the average miles per hour (MPH) the truck operates. The average MPH figure times the hour interval, from the "Lubrication and Maintenance Chart" will give you the approximate number of miles to be used for oil and filter changes.

Example: 600 miles of truck operation per week divided (÷) by an average 30 hours per week of engine operation, equals (=) an average of 20 miles per hour (MPH), times a 300 hour change interval, equals (=) 6000 miles approximately for the oil and filter change interval.

To use the "Mileage Oil and Filter Change Interval Chart" shown below, determine the hour change interval from the "Lubrication and Maintenance Chart" by the classification of oil used and the crankcase capacity.

Use this hour figure and the calculated average MPH figure as cross reference on the chart, to determine the approximate mileage interval for oil and filter changes. This mileage figure may be written in the blank space provided in the "Lubrication and Maintenance Chart" under "Oil and Filter Change Interval."

Mileage Oil and Filter Change Interval Chart (Approximate)

Average MPH (km/h)	Oil Change Interval in Hours		
	150 hr.	200 hr.	300 hr.
10 (16)	1,500 mi 2,400 km	2,000 mi 3,200 km	3,000 mi 4,800 km
15 (24)	2,250 mi 3,600 km	3,000 mi 4,800 km	4,500 mi 7,250 km
20 (32)	3,000 mi 4,800 km	4,000 mi 6,500 km	6,000 mi 9,600 km
25 (40)	3,750 mi 6,000 km	5,000 mi 8,000 km	7,500 mi 12,000 km
30 (48)	4,500 mi 7,250 km	6,000 mi 9,600 km	9,000 mi 14,500 km
35 (56)	5,250 mi 8,500 km	7,000 mi 11,000 km	10,500 mi 17,000 km
40 (64)	6,000 mi 9,600 km	8,000 mi 13,000 km	12,000 mi 19,000 km

Refill Capacities — (Approximate)

Compartment or System	U.S. Quarts	Liters	Imperial Quarts
ENGINE CRANKCASE including FILTERS(1)			
Serial No. 32Y68441-Up, 51Z1-Up	18	17	15
Serial No. 40S1-Up	12(2) or 14	11.5(2) or 13	10(2) or 11.5
Serial No. 2Z1-Up(3) (California arrangements only)	18	17	15
Serial No. 2Z1-Up(4) (all arrangements except California)	20	19	16.5
Serial No. 32Y32181-32Y68440	14	13	11.5
Serial No. 32Y1 - 32Y32180	12(2) or 14	11.5(2) or 13	10(2) or 11.5
Cooling System - See Truck Mfg. Specifications			

(1)Additional oil is required with the use of auxiliary filters. Make sure to add enough oil to fill the auxiliary oil circuit.

(2)These engines originally had an 11.5 liters (12 U.S. quarts) capacity. The dipsticks on these engines should be re-marked for 13 liters (14 U.S. quarts) capacity. Consult your Caterpillar engine dealer for procedure.

(3)Turbocharged engines WITHOUT piston cooling jets should use these refill capacities. These engines will have an engine oil cooler that is approximately 254 mm (10" long).

(4)Turbocharged engines WITH piston cooling jets should use these refill capacities. These engines will have an engine oil cooler that is approximately 356 mm (14" long).

NOTE: For remanufactured engines, use the Reference Serial No. (REF. SER. NO.) to determine the crankcase refill capacity. Remanufactured engines with RER. SER. NO. 40S1-Up and 32Y1-32Y68440 have the correct dipstick markings for 13 liters (14 U.S. quarts) capacity.

Oil and Filter Change Interval (Service Hours of Engine Operation)

Crankcase Refill-Capacity Including Filters (U.S. Quarts)	Minimum API Oil Classification When Diesel Fuel Sulfur Content is 0.5% or Less	
	CD/SE or CD/SF(1)	CC/SE or CC/SF(1)
18 and 20 quarts (Turbocharged Engines)	300 Service Hours	Not Recommended(3)
18 quarts (Non-Turbocharged Engines)	300 Service Hours	200 Service Hours
18 quarts (Non-Turbocharged Engines) California L.E.S.(2)	200 Service Hours L.E.S.(2)	150 Service Hours L.E.S.(2)
14 quarts (Non-Turbocharged Engines)	200 Service Hours	150 Service Hours

(1)If fuel contains more than 0.5% sulfur use only CD/SE or CD/SF oil with a TBN of 20 times the percentage of fuel sulfur.

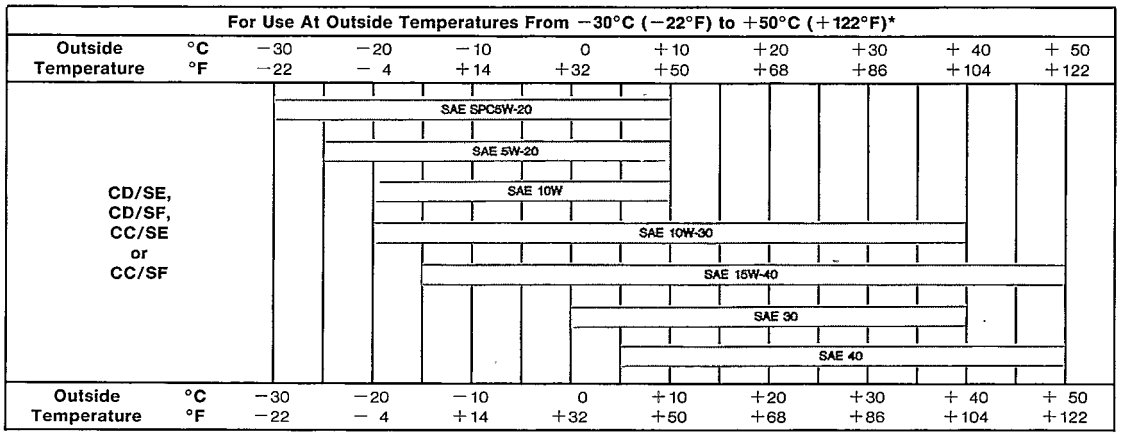
(2)Naturally Aspirated engines equipped with Low Emission System (L.E.S.) exhaust gas recirculation.

(3)CC/SE and CC/SF oils are not recommended for turbocharged engines.

Coolant Conditioner

Cooling system coolant conditioner is necessary to prevent cylinder wall pitting. Most antifreeze solutions DO NOT contain sufficient coolant conditioners. See topics "Cooling System," "Coolant, Fuel and Lubricant Specifications" and "Maintenance Recommendations."

Recommended Lubricant Viscosities


For Use At Outside Temperatures From −30°C (−22°F) to +50°C (+122°F)*
Outside Temperature °C −30 −20 −10 0 +10 +20 +30 +40 +50
Outside Temperature °F −22 −4 +14 +32 +50 +68 +86 +104 +122
CD/SE, CD/SF, CC/SE or CC/SF
SAE SPCSW-20
SAE 5W-20
SAE 10W
SAE 10W-30
SAE 15W-40
SAE 30
SAE 40

*When operating below −30°C (−22°F) refer to the Cold Weather Operation Guide, Form SEBU5338, available from your Caterpillar dealer.

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Lubrication and Maintenance Chart

Item	Service	Lube.	Page
Daily			
Engine Crankcase(2)	Measure oil level. (Engine Stopped)	(2) CD/SE, CD/SF, CC/SE or CC/SF	24
Cooling System	Check coolant level — inspect.		24
Water Separator	Drain water and sediment — inspect.		25
Air Tank (If Equipped)	Drain water and sediment.		27
Under the Hood Inspection	Inspect engine compartment.		27
First Oil Change Interval Only — New, Rebuilt or Remanufactured Engines			
Engine Valve Lash **NOTE:** Check and adjust at first oil change interval. Then Every 1200 Service Hours or One year.	Check and adjust valve lash at the first scheduled oil change interval, due to initial wear and seating of valve train components.		29
Oil and Filter Change Interval Every _____ Service Hours or 3 Months or _____ km (_____ Miles) Whichever Occurs First			
Engine Crankcase(2) **NOTE:** Make sure to fill in the number of service hours in the blank space above for the oil and filter change interval. This interval in service hours is determined by the crankcase capacity and the API classification of oil used. Refer to the two charts on page 22.	Change oil and filters — if mileage figures are to be used to determine the service interval, see page 21 "Oil and Filter Change Interval (Mileage)" for method and procedure.	**CD/SE, CD/SF, CC/SE or CC/SF (2)**	30
Fuel Filters	Replace.		32
Engine Crankcase Breather (If Equipped)(1)	Clean.		34
Cooling System	Add coolant conditioner or replace element. Clean radiator fins — inspect.		34
Air Cleaner	Clean or replace elements-or at interval recommended by truck manufacturer.		36
Batteries	Clean — check electrolyte level.		38
Alternator, Fan and Accessory Drive Belts	Check — adjust.		38
*Low Emission System (L.E.S.)	Check for correct operation.		39
Every 1200 Service Hours or One Year or _____ km (_____ Miles) Whichever Occurs First			
Engine Valve Lash	Check and adjust.		40
Air-Fuel Ratio Control (Turbocharged)	Check setting — adjust if necessary.		43
*PCV Valve (If Equipped)	Check diaphragms — replace if necessary.		43
Thermostats	Check — replace if necessary.		44
*Turbocharger (If Equipped)	Check — repair or replace if necessary.		45
Vibration Damper	Check — replace if necessary.		45
Every 2400 Service Hours or Two Years or _____ km (_____ Miles) Whichever Occurs First			
Coolant and PCV Hoses	Replace.		46
Cooling System	Clean, conditioner precharge.		47
*Fuel Injection Nozzles	Test — replace if necessary.		49
Governor	Check full load speed (set point) and low idle rpm.		52

PM-1

PM-2

PM-3

NOTE: Mileage and kilometer figures have been left blank and will need to be filled in, if mileage figures are used to determine the service intervals. Calculate the average miles per hour (mph) or kilometers per hour (km/h) the truck operates. Multiplying the average mph or km/h figure times (X) the number of service hours for each service interval will equal (=) the service interval in miles or kilometers. Enter this mileage or kilometer figure in each appropriate blank space in the chart and in the page heading.

*Emission control required maintenance scheduled items.

(1)Engines equipped with Low Emission System (L.E.S.) exhaust gas recirculation.

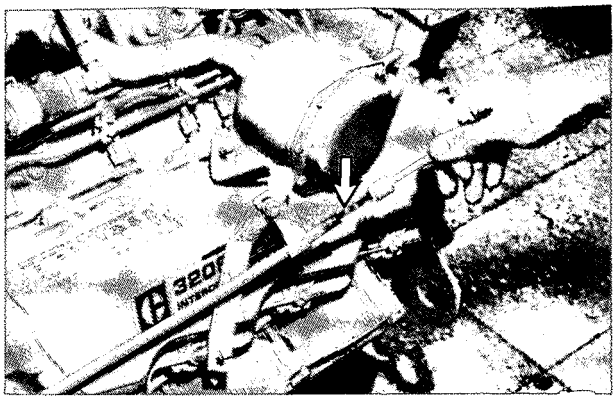
(2)CC/SE and CC/SF oils are not recommended for turbocharged engines.

Engine Crankcase

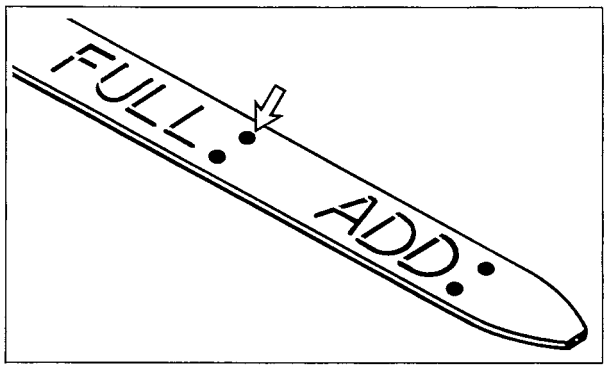
Measure Oil Level (Engine Stopped)

⚠ WARNING

Hot oil and components can cause personal injury. Do not allow hot oil or components to contact skin.



1. Measure the oil level.



2. Maintain the oil level between the FULL and ADD marks on the dipstick. Do not fill the crankcase above the FULL mark.

3. Add oil if necessary.

Cooling System

Check Level — Inspect

⚠ WARNING

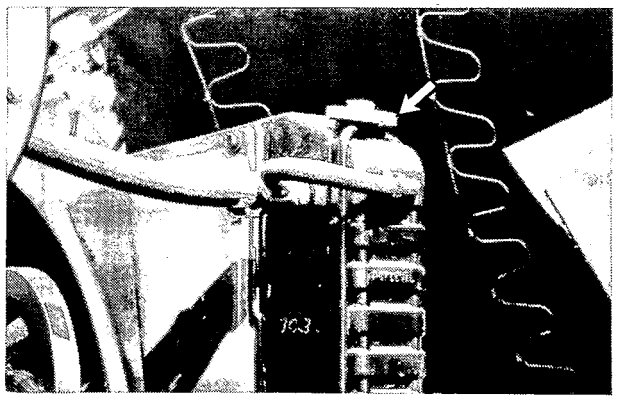
At operating temperature, the engine coolant is hot and under pressure.

Steam can cause personal injury.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to touch with your bare hand.

Remove the filler cap slowly to relieve pressure.

Cooling system conditioner contains alkali. Avoid contact with the skin and eyes to prevent personal injury.



1. Check the coolant level with the engine stopped and cold.

2. Remove the radiator cap slowly to relieve any pressure.

3. Maintain the coolant level within 13 mm (1/2 inch) below the bottom of the fill pipe or to the proper level on the sight glass, if so equipped.

4. Inspect the radiator cap. Replace it if damaged. Install the radiator cap.

5. Inspect and clean the radiator fins.

Water Separator

Drain Water and Sediment

⚠ WARNING

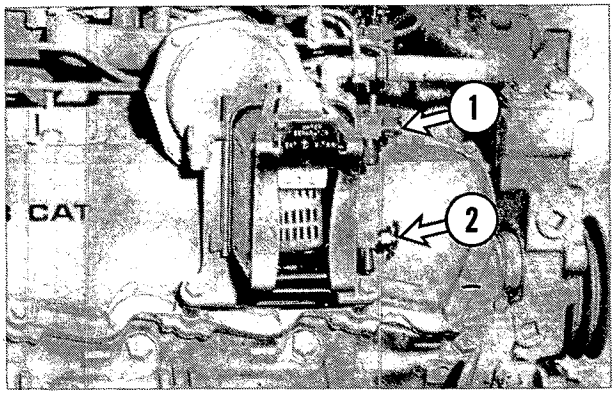
Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

Turn the disconnect switch OFF or disconnect the battery when changing fuel filters or water separator elements. Drain the fuel from the water separator into a container before removing the water separator retaining clamp.

NOTICE

The engine should never be allowed to run with the water level in the separator more than 1/2 full or engine damage may result.

NOTE: The water separator is not a filter. It separates water from the fuel.



1. Drain water from the separator daily before starting the engine.

2. Close the fuel supply line, if equipped.

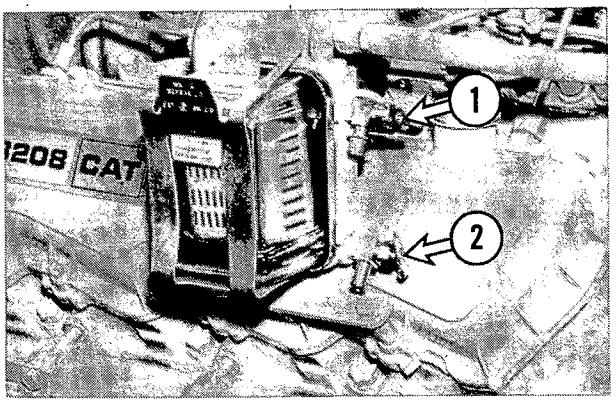
3. Open vent valve ① and drain valve ②. Allow the water to drain.

4. Close vent valve ①, drain valve ② and open the fuel supply valve, if equipped.

Replacing

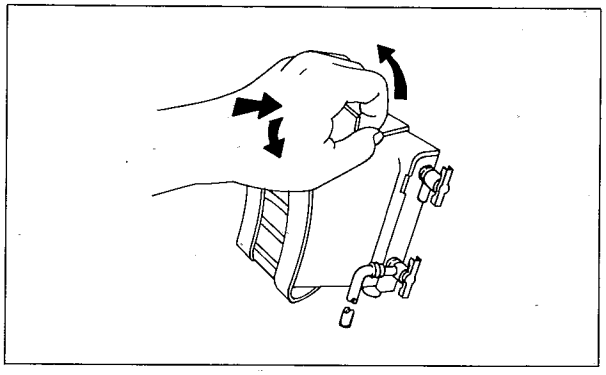
NOTE: Change element anytime the water separator becomes contaminated enough that water level cannot be seen through the transparent cover.

1. Close the fuel supply valve, if equipped.

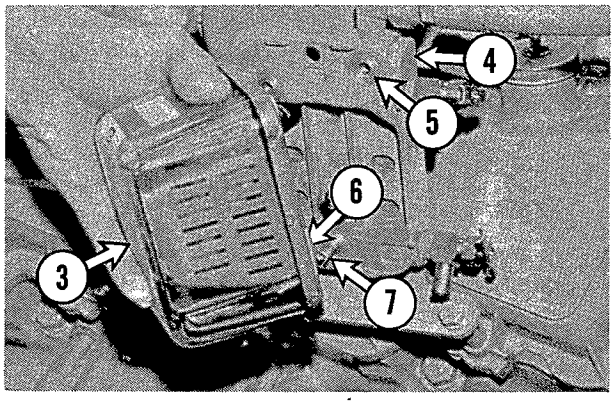


2. Remove all dirt from the separator and surrounding area.

3. Open vent valve ① and drain valve ②. Allow fuel to drain. Close valves ① and ②.



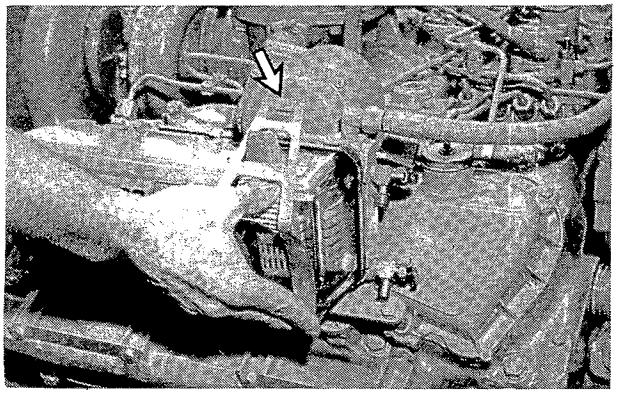
4. To remove the water separator element, depress the extended tab with the heel of the hand. Then lift the slotted tab from the locking slot, at the top of the base, with the fingers. Remove the clamp.



5. Remove element ③ from base ④ and discard it.

6. Clean the three sealing surfaces ⑤ on base ④ before installing a new element.

7. Align outlet hole ⑥ and roll pin ⑦ and push new element ③ into position on the base.



8. The clamp must be installed with the hand and finger tabs in the UP position.

9. Engage lower tab of clamp in slot at bottom of separator base. While depressing clamp, with heel of hand, push upper tab into locking slot at top of base.

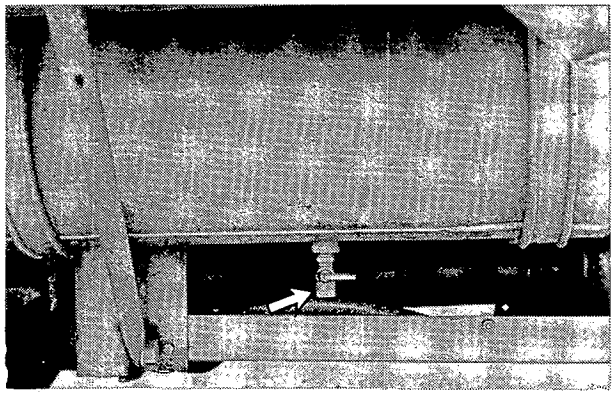
10. Open the fuel supply valve, if equipped.

11. Prime the fuel system. See "Priming the System" under item "Fuel Filters."

12. Start the engine and check for fuel leaks.

Air Tank (If Equipped)

Drain Water and Sediment



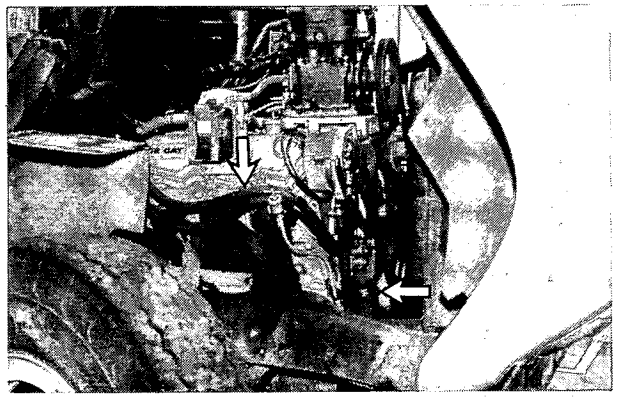
1. Open the drain valve on the air tank and drain the water and sediment. Close the valve.

Under the Hood Inspection

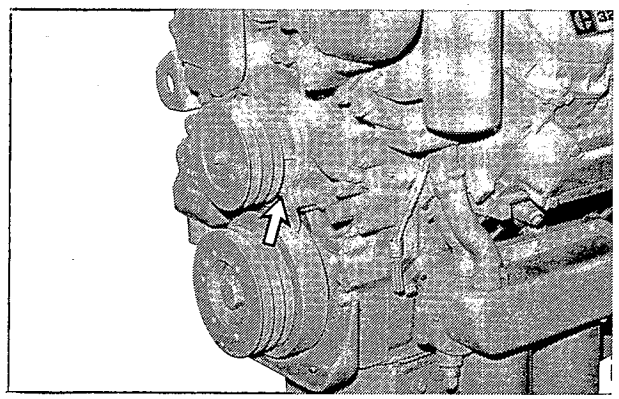
Inspect the Engine Compartment

For your own safety and maximum service life of the engine, make a thorough inspection under the hood before starting the engine.

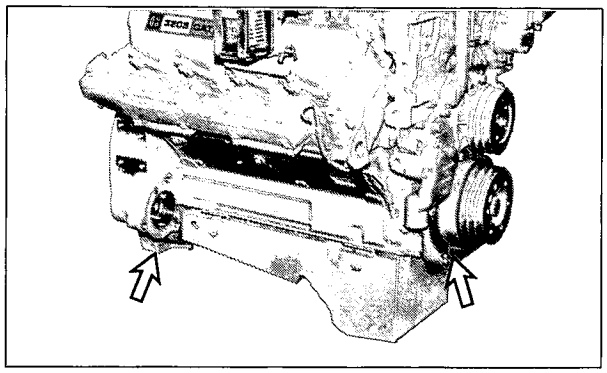
Look for such items as loose bolts, debris buildup, oil and coolant leaks. Remove all debris and have repairs made as needed.



1. Inspect all cooling system hoses for cracks, splits and leakage. Tighten hose clamps if neessary.

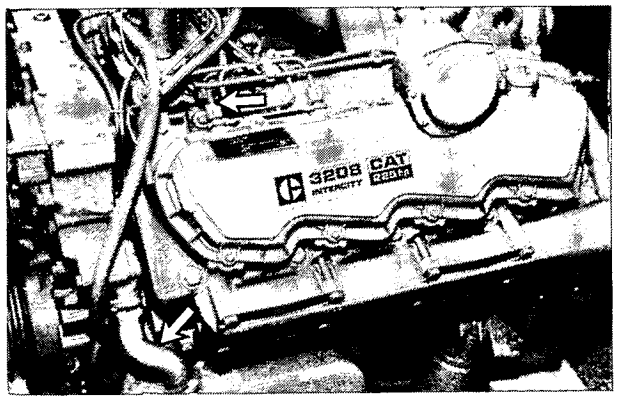


2. Inspect the water pump for coolant leaks. Slight evidence of coolant from the drain hole is normal. Only with consistant measurable coolant loss should the water pump be replaced.



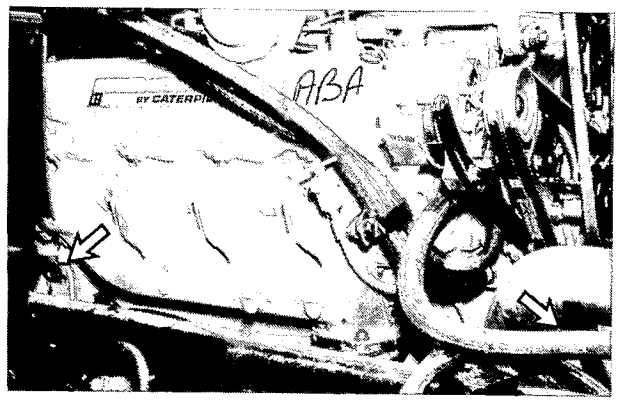
3. Inspect for excessive oil leakage from the front and rear crankshaft seals.

4. Look on the ground for an indication of oil or coolant leaks.



5. Inspect for any fuel leakage at connections, lines and hoses.

6. Inspect the oil cooler and PCV hoses for leaks or damage.



7. Inspect engine mounting bolts for looseness.

8. Inspect all wiring for worn or frayed insulation and loose connections.

9. Make sure the engine-to-frame ground strap connection is clean and tight.

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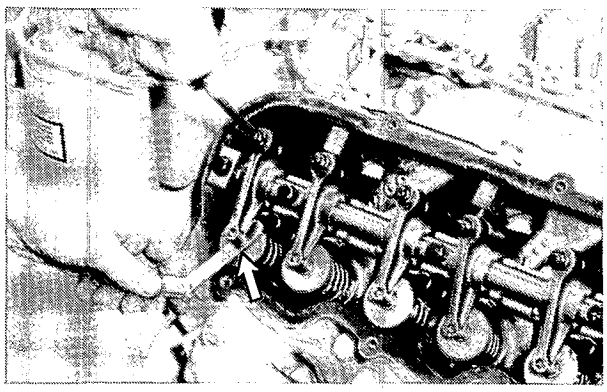
Engine Valve Lash

Check and Adjust



Initial valve lash adjustment on new, rebuilt or remanufactured engines is recommended at the first scheduled oil change interval, due to initial wear and seating of valve train components.

For the procedure, see topic "Engine Valve Lash" in "Every 1200 Service Hours or 1 Year, Whichever Occurs First."

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Engine Crankcase

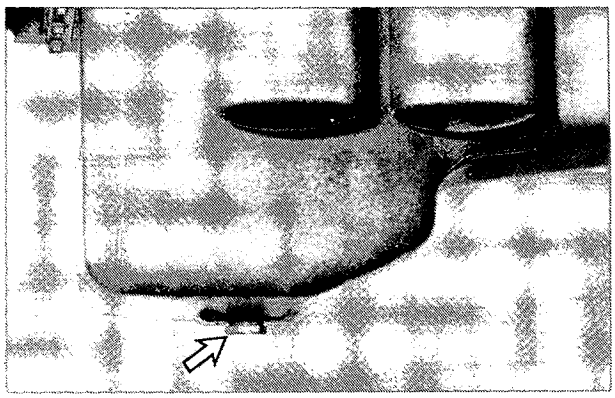
Change Oil and Filters

The percentage of sulfur in the fuel will affect the engine oil recommendations. If the fuel has over 0.5% sulfur content, the CD/SE or CD/SF engine oil must have a TBN of 20 times the percentage of fuel sulfur (TBN as measured by the ASTM D-2896 method). Your oil supplier should be able to furnish the correct oils.

⚠ WARNING

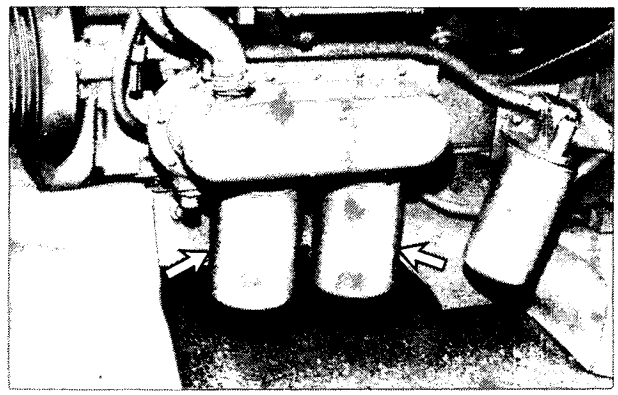
Hot oil and components can cause personal injury. Do not allow hot oil or components to contact skin.

Drain the crankcase with the oil warm and the engine stopped.



1. Remove the crankcase drain plug and allow the oil to drain.

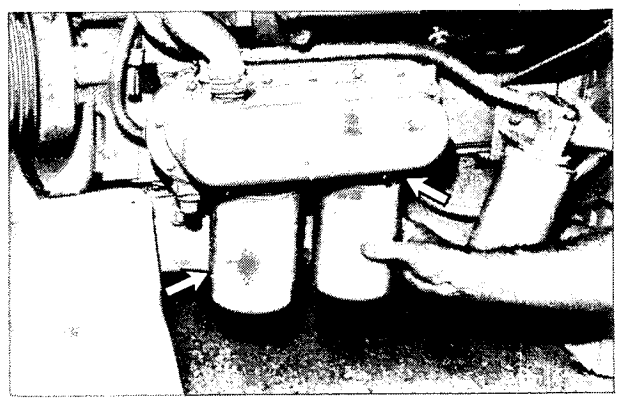
2. Install the crankcase drain plug and tighten it to 70 ± 14 N·m (50 ± 10 lb ft).



3. Remove and discard the oil filters.

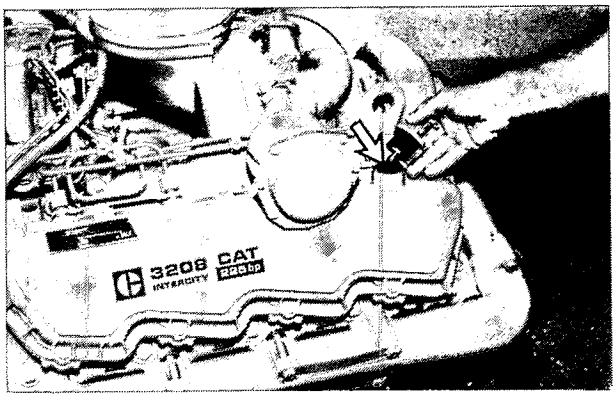
4. Wipe the sealing surface of the filter element mounting base. Make sure all of the old gaskets are removed.

NOTE: Make sure to use the correct oil filter element for your engine arrangment.



5. Apply a small amount of clean engine oil to the new filter element gaskets.

6. Install the new filter elements by hand until the gasket contacts the base. Tighten the filters 3/4 of a turn more with a filter wrench. Do not overtighten.



7. Fill the crankcase. See "Refill Capacities."

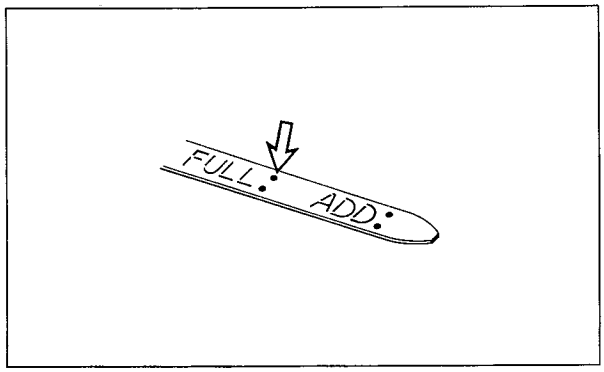
NOTICE

If equipped with auxiliary oil filters, extra oil must be added when filling the crankcase.

If the extra oil is not added, the auxiliary oil filter will take priority and the engine may starve for oil.

8. Before starting the engine, check the oil level. The oil level should be at or above the FULL mark on the dipstick.

9. Start and run the engine at low idle for two minutes. Inspect for oil leaks. Stop the engine.



10. Wait 10 minutes to allow the oil to drain back into the crankcase. Check the oil level. Maintain the oil level to the FULL mark on the dipstick.

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Fuel Filters

Replace

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

Turn the disconnect switch OFF or disconnect the battery when changing fuel filters.

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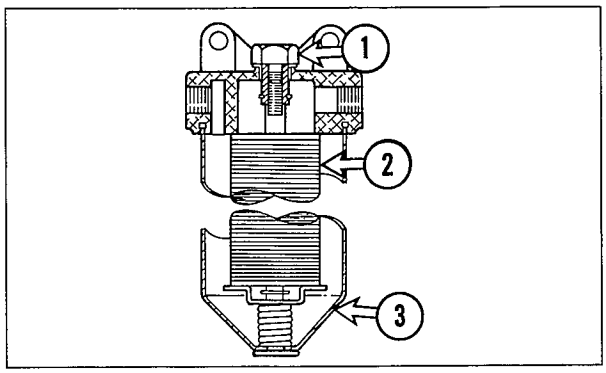
1. Stop the engine.

2. Shut off the fuel tank supply valve.

Primary Filter (If Equipped)

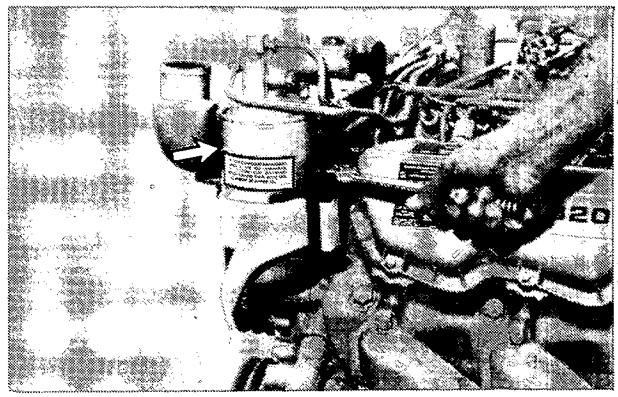


1. Loosen nut ① on the filter housing and remove filter case ③.

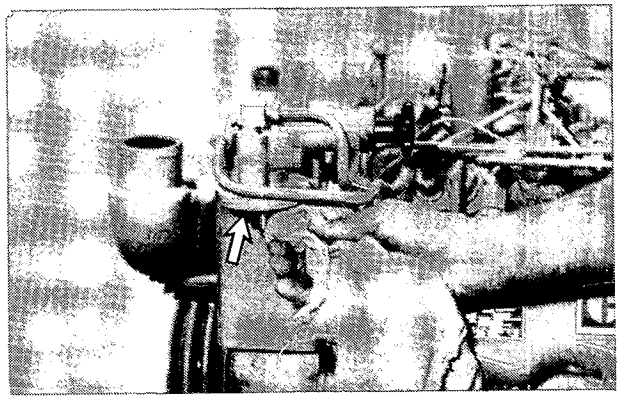
2. Remove element ② and wash it in clean, nonflammable solvent.

3. Install element ② and case ③. Tighten nut ①.

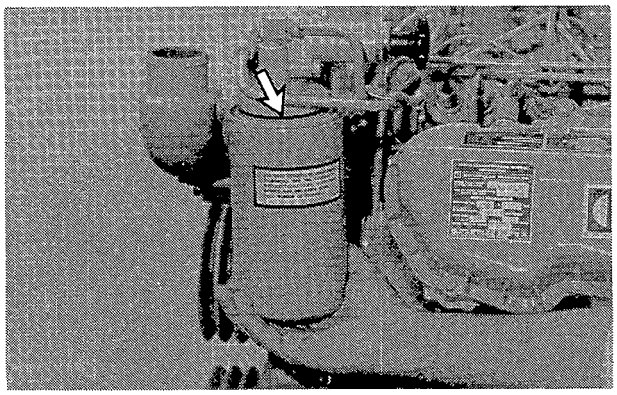
Final Fuel Filter



1. Remove and discard the fuel filter element.



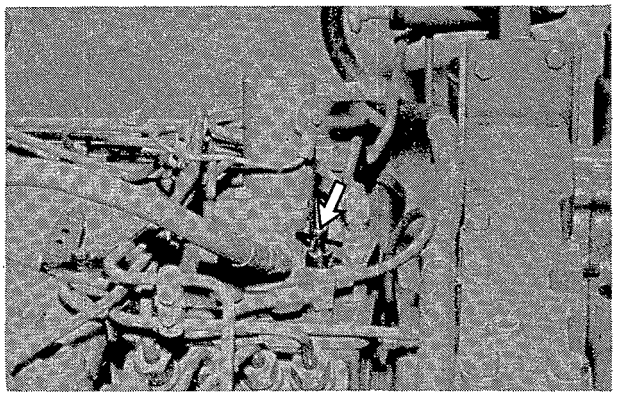
2. Clean the gasket sealing surface of the filter base. Make sure all of the old gasket is removed.



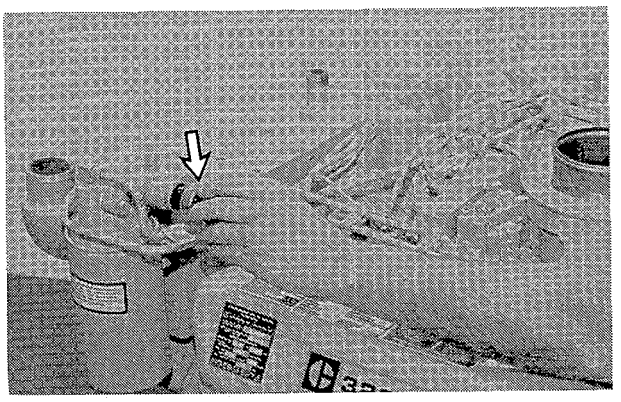
3. Apply clean diesel fuel to the fuel filter gasket.

4. Install the filter and tighten by hand until the filter gasket contacts the base. Tighten the filter 1/2 to 3/4 turn more with a filter wrench.

Priming the System



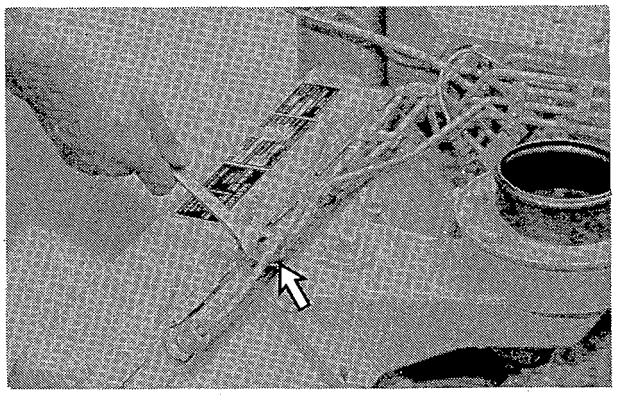
1. Open the vent valve on the fuel injection pump housing and turn on the fuel tank supply valve.



2. Unlock and operate the priming pump plunger until the flow of fuel from the vent valve is continuous and free of bubbles.

3. Close the vent valve and lock the priming pump plunger.

4. Start the engine. If the engine will not start, continues to misfire or smoke, further bleeding is necessary.



5. Loosen the fuel line nuts at the cylinder head.

6. Crank the engine until fuel flows free of air bubbles.

7. Tighten the fuel line nuts to 40 ± 7 N·m (30 ± 5 lb ft).

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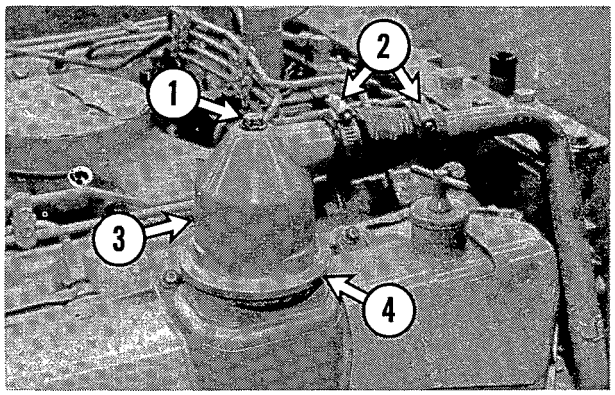
Oil and Filter Change Interval - Every _____ Service Hours or 6 Months
or _____ km (_____ Miles) Whichever Occurs First

Engine Crankcase Breather (If Equipped)

Clean

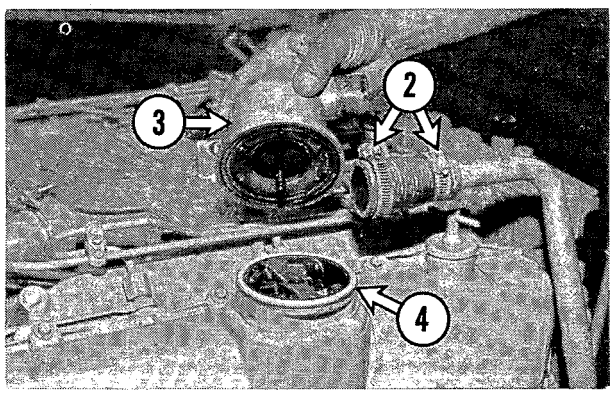
NOTE: Truck engines equipped with Low Emission System (L.E.S.) do not use PCV valves. A crankcase breather is used on the valve cover.



1. Loosen hose clamps (2) and slide the hose on to the tube.

2. Loosen bolt (1), remove breather (3) and seal (4).

3. Wash breather (3) in clean, nonflammable solvent and dry it.



4. Install a new seal (4) and the clean breather (3). Tighten bolt (1) to 14 ± N·m (10 ± 2 lb ft).

5. Slide the hose on to breather (3) and tighten hose clamps (2).

Cooling System

Add Conditioner or Replace Element

⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure.

Steam can cause personal injury.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to touch with your bare hand.

Remove the filler cap slowly to relieve pressure.

Cooling system conditioner contains alkali. Avoid contact with the skin and eyes to prevent personal injury.

NOTICE

All water is corrosive at engine operating temperature. Use Caterpillar liquid cooling system conditioner or Caterpillar cooling system conditioner element to treat either plain water or ethylene glycol antifreeze solution.

Never use both the liquid cooling system conditioner and the conditioner element at the same time.

NOTE: See "Know Your Cooling System" Form SEBD0518 and your Caterpillar dealer for more detailed specifications.

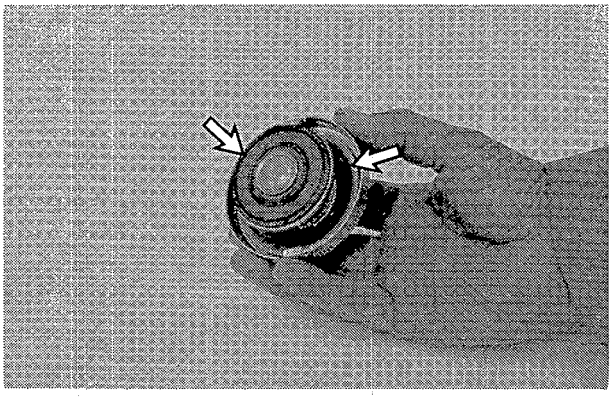
Liquid Conditioner

1. Loosen the radiator cap slowly to relieve pressure and remove the cap.

2. It may be necessary to drain enough coolant from the radiator to allow for the addition of the liquid cooling system conditioner.

3. Add 0.24 liters (1/2 pint) of Caterpillar liquid cooling system conditioner for every 38 liters (10 U.S. gallons) of cooling system capacity.

NOTE: On new, rebuilt or remanufactured engines only or when changing the coolant, add enough liquid conditioner for a 3% to 6% concentration of conditioner. Add 0.95 liters (1 quart) for every 30 liters (8 U.S. gallons) of cooling system capacity.



4. Inspect the radiator cap gaskets. Replace the cap if the gaskets are damaged.

5. Install the radiator cap.

Conditioner Element (If Equipped)

1. Close the coolant conditioner element inlet and outlet valves.

2. Remove and discard the conditioner element.

3. Clean the element mounting base. Make sure all of the old gasket is removed.

4. Coat the gasket of a new maintenance conditioner element with a thin film of engine oil. Install the new conditioner element.

NOTE: On a new,rebuilt or remanufactured engine, use a precharge conditioner element for original fill of the cooling system.

5. Open the inlet and outlet valves.

6. Remove the radiator cap.

7. Start the engine and check for leaks. Allow the coolant level to stabilize.

8. Add coolant if necessary to bring the coolant to within 13 mm (1/2 inch) below the bottom of the fill pipe or to the proper level on the sight glass, if so equipped.

9. Inspect the radiator cap. Replace the cap if the gasket is damaged. Install the cap.

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Oil and Filter Change Interval - Every _____ Service Hours or Months or _____ km (_____ Miles) Whichever Occurs First

Engine Air Cleaner

Service the engine air cleaner at regular intervals determined by dust conditions. See the truck manufacturer's operator's guide for detailed information.

A service indicator may be mounted on the instrument panel or in the engine compartment. A colored piston showing in the window indicates the need for servicing the air cleaner. Replace the filter element at least once a year.

NOTICE

Never service the air cleaner with the engine running.

Changing Air Cleaner Elements

1. Loosen the retaining bolts and remove the end cover on the air cleaner housing.

2. Remove and inspect the element for damaged pleats, gaskets or seals. Replace the element if damaged.

3. Clean the inside of the housing.

4. Install a new or cleaned element in the air cleaner housing.

5. Install the end cover on the air cleaner housing.

6. Reset the service indicator by pushing on the piston plunger.

Cleaning Air Cleaner Elements

⚠ WARNING

Pressure air can cause personal injury.

When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.

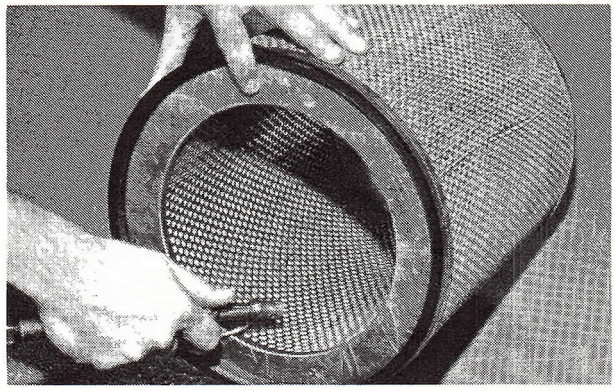
NOTICE

Do not clean filter elements by bumping or tapping.

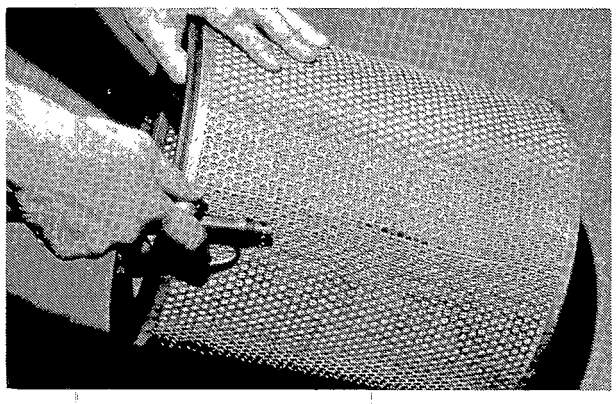
Do not use filter elements with damaged pleats, gaskets or seals.

NOTE: Air cleaner filter elements can be cleaned with either air, water or detergent. Have spare elements on hand to use while cleaning used elements.

Pressure Air — 205 kPa (30 psi) Maximum Pressure

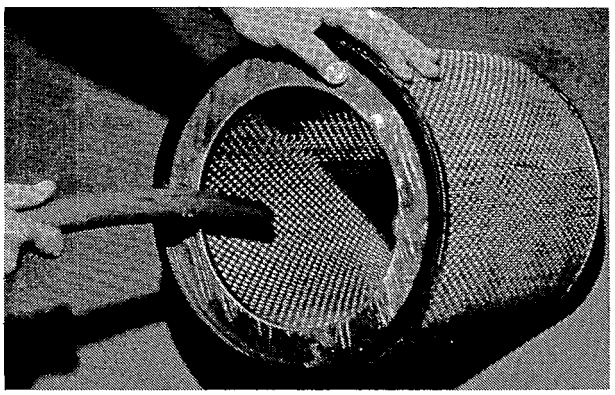


1. Direct air inside of the element along the length of the pleats.

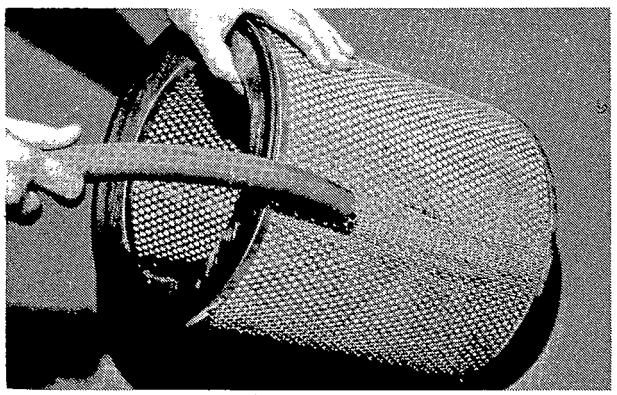


2. Direct air on the outside of the element along the length of the pleats. Direct air on the inside along the pleats. Inspect the element for any rips, tears or damage.

Pressure Water — 280 kPa (40 psi) Maximum Pressure

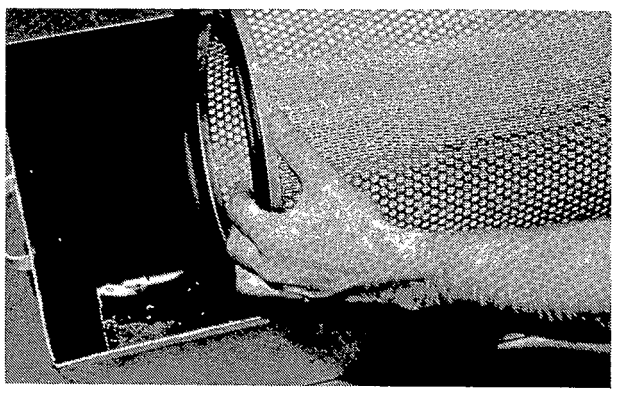


1. Direct water on the inside of the element, along the length of the pleats.



2. Direct water on the outside of the element along the length of the pleats. Air dry thoroughly before using and inspect the element.

Detergent



1. Wash the element in warm water and nonsudsing detergent.

2. Rinse the element with clean water. See instruction for cleaning with water.

3. Air dry it thoroughly before using and inspect the element.

Inspecting Element

1. Insert a light inside of the cleaned and dry element. Inspect it for rips and tears. Discard the element if damaged.

2. Wrap and store good cleaned elements in a clean, dry place.

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Batteries

Clean — Check Electrolyte Level

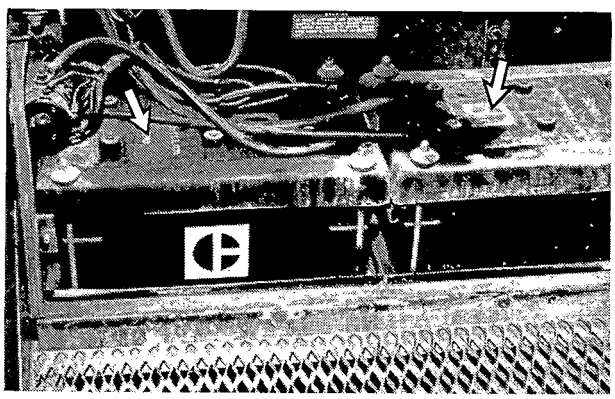
⚠ WARNING

Batteries give off flammable fumes that can explode.

Do not smoke when observing the battery electrolyte levels.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

Always wear protective glasses when working with batteries.



1. Clean the top of the batteries.

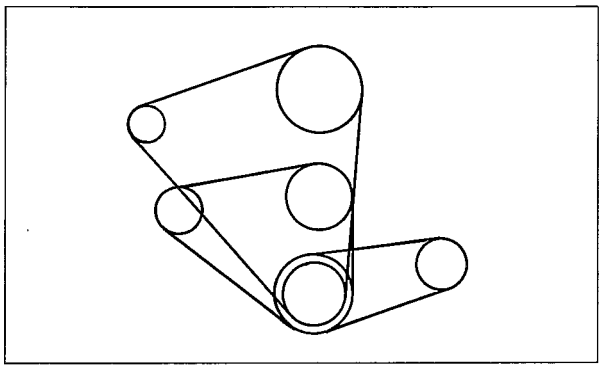
2. Remove the filler caps. Maintain the electrolyte level to the bottom of the filler openings. If an addition of water is necessary, use distilled water. If not available, use clean water, low in minerals. Do not use artificially softened water.

At proper charging rate, batteries should not require more than 30 cc (1 ounce) of water per cell per week.

3. Install filler caps.

Alternator, Fan and Accessory Drive Belts

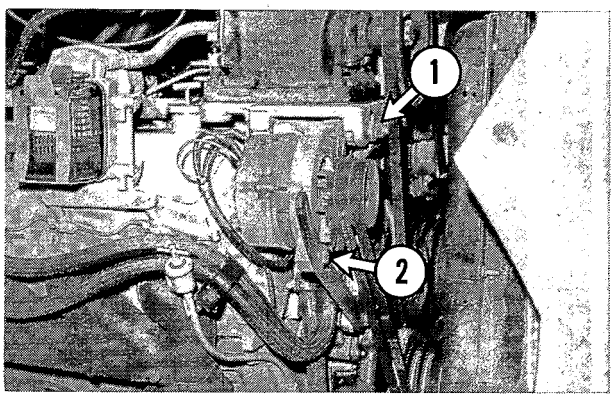
Inspect — Adjust



1. Inspect the condition and adjustment of the belts.

2. To check the belt tension, apply 110 N (25 lbs) of force midway between the pulleys. Correctly adjusted belts will deflect 13 to 19 mm (1/2 to 3/4 inch).

To Adjust



1. To adjust the alternator drive belt, loosen mounting bolt ① and the adjusting bracket bolt ②.

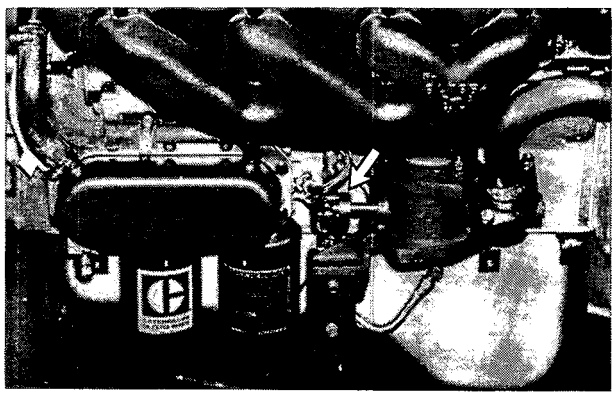
2. Move the alternator in or out as required to obtain the correct adjustment.

3. Tighten bolts ① and ②.

4. If new belts are installed, check belt adjustment again after 30 minutes of engine operation.

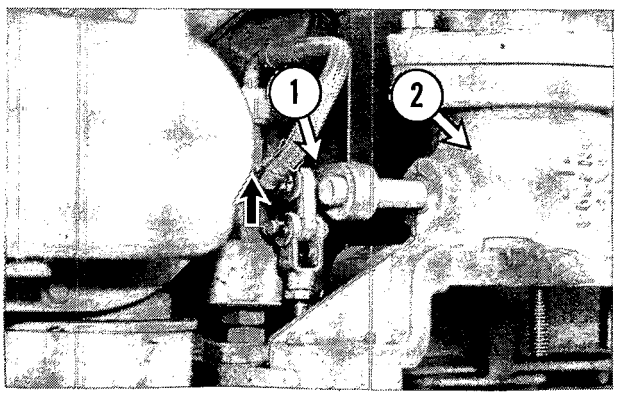
Low Emission System (If Equipped)

Check



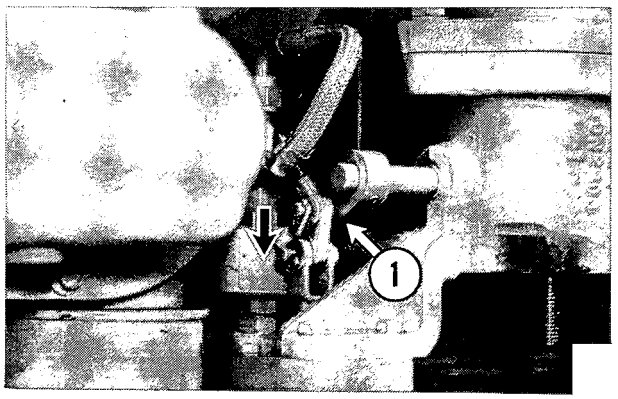
Visually check the low emission system for correct operation at each oil change of the engine.

Engine Stopped



With the engine stopped lever ① on, valve ② should be in the UP position, slightly above horizontal, as shown.

Engine Running at Idle



1. With the engine started and running at low idle speed, lever ① should be in the DOWN position, below horizontal, as shown.

2. If lever ① does not move to the DOWN position, have the low emission system tested and repaired.

NOTE: For testing and adjusting, refer to the "Low Emission System" Section in the Service Manual, Form SEBR0514.

The Caterpillar 6V3060 System Tester has been designed to test (troubleshoot) the low emission system for correct operation. See Special Instruction, Form SEHS7808, for instruction on the use of the tester.

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Engine Valve Lash

Check — Adjust

NOTE: Initial valve lash adjustment on new, rebuilt or remanufactured engines only, is recommended at the first scheduled oil change interval, due to initial wear and seating of valve train components.

When the valve lash (clearance) is checked, an adjustment is NOT necessary if the measurement is within the range given in the "Valve Clearance Check" chart shown below.

Valve Clearance Check	
Intake	0.30 to 0.46 mm (.012 to .018 in)
Exhaust	0.56 to 0.71 mm (.022 to .028 in)

If the measurement is outside of the valve clearance check range shown above, an adjustment is necessary. Set the clearance to the nominal clearance given in the "Valve Clearance Setting" chart shown below.

Valve Clearance Setting	
Intake	0.38 mm (.015 in)
Exhaust	0.64 mm (.025 in)

To Check and Adjust Valve Lash (Clearance)

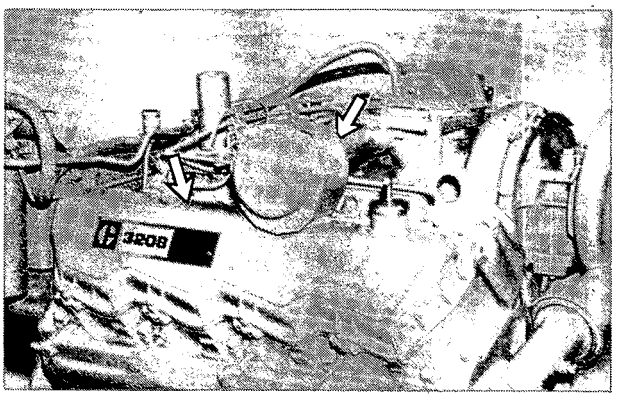
1. Disconnect the battery or the wire to the shutoff solenoid on the fuel injection pump.

⚠ WARNING

To prevent possible injury, be sure fuel system is shut off and do not use the starter motor to turn the flywheel. Engine may start.

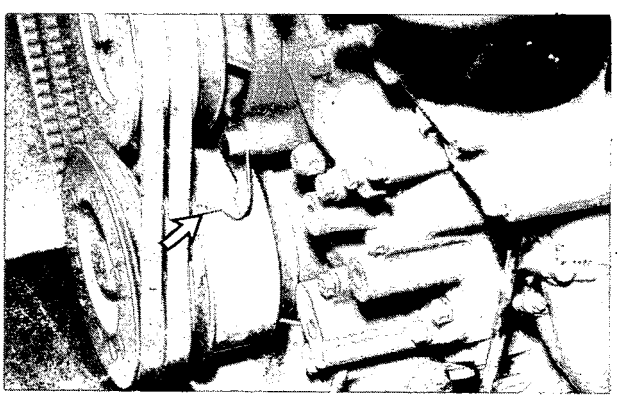
NOTICE

Adjust the valve lash (clearance) only with the engine stopped. Always turn the flywheel in the direction of normal rotation, which is clockwise, as viewed from the front of the engine.



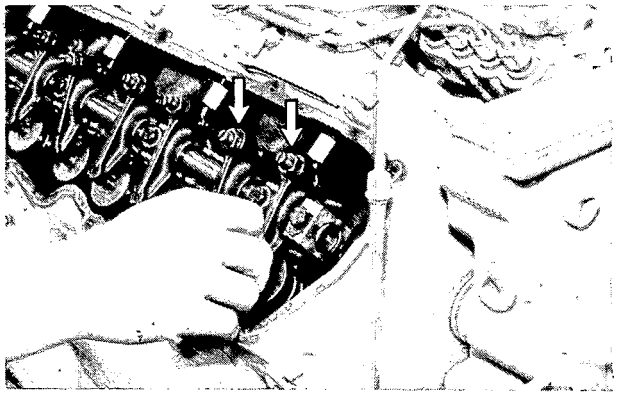
2. Loosen hose clamps on the crankcase ventilation valves or the crankcase breather and slide the hose away from them.

3. Clean around the valve covers. Remove both valve covers.

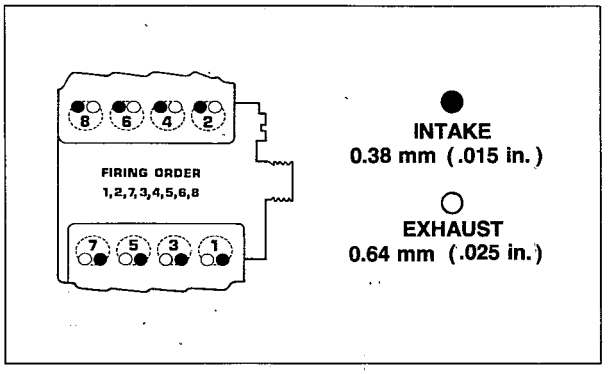


4. Turn the crankshaft clockwise (as viewed from the front of the engine) until No. 1 cylinder is on top dead center (TDC-1) compression stroke.

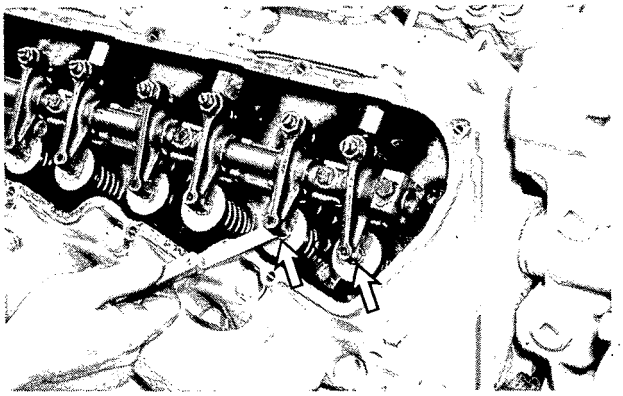
5. Align the TDC-1 mark on the damper with the timing pointer located on the front of the engine block.



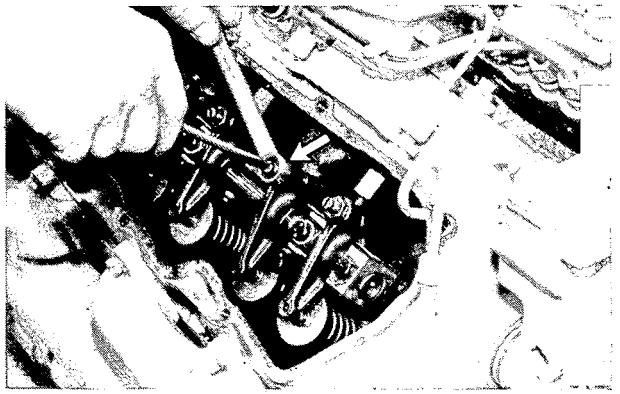
6. Both the exhaust and inlet valves for No. 1 and No. 2 cylinders will be closed. The four rocker arms should move with finger pressure. If both valves for No. 1 cylinder are not closed, rotate the engine 360° to obtain TDC-1 compression.



7. To adjust valve lash, use clearances shown above. The numbering of cylinders and valve location are also shown.



8. Check and adjust (if necessary) the intake and exhaust valve lash for No. 1 and No. 2 cylinders.



9. Loosen the valve adjusting screw locknut.

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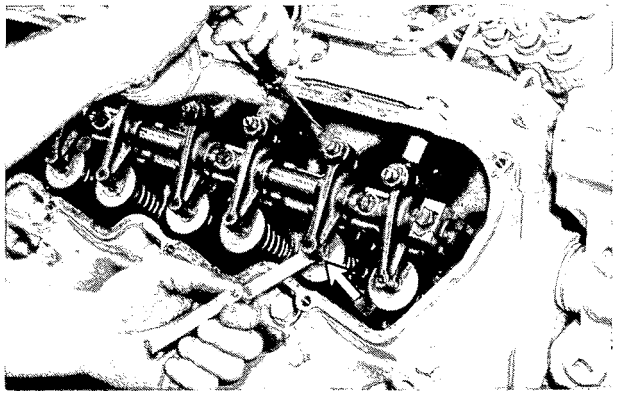
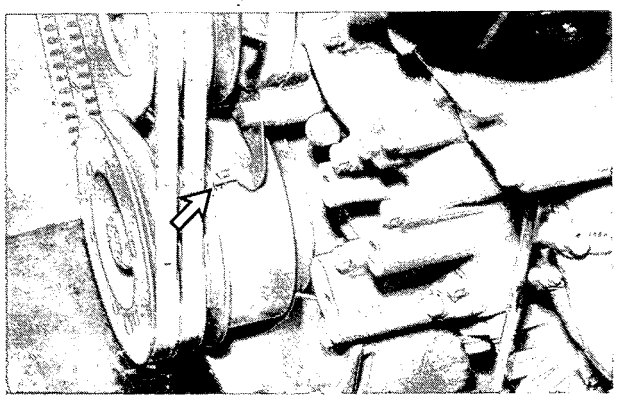


10. Turn the adjusting screw until a feeler gauge of the correct thickness (see chart) can be inserted between the valve stem and the rocker arm.

11. When the correct adjustment is obtained, hold the adjusting screw and tighten the locknut to 32 ± 7 N·m (24 ± 5 lb ft).

12. After the locknut is tightened, check the adjustment again.



13. Turn the crankshaft 180° clockwise (as viewed from the front of the engine). On later engines align the VS timing mark on the damper with the timing pointer.

14. Check and adjust (if necessary) the intake and exhaust valve lash for No. 3 and No. 7 cylinders.

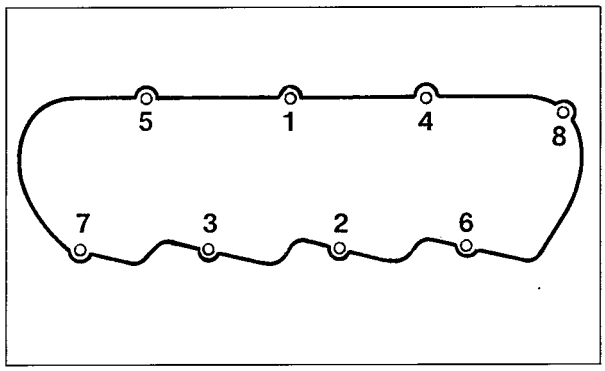
15. Turn the crankshaft 180° clockwise (as viewed from the front of the engine). Align the TDC-1 mark on the damper with the timing pointer.

16. Check and adjust (if necessary) the intake and exhaust valve lash for No. 4 and No. 5 cylinders.

17. Turn the crankshaft 180° clockwise (as viewed from the front of the engine). Align the VS timing mark on the damper with the timing pointer.

18. Check and adjust (if necessary) the intake and exhaust valve lash for No. 6 and No. 8 cylinders.

19. Inspect the valve cover gaskets. Install new gaskets if necessary.



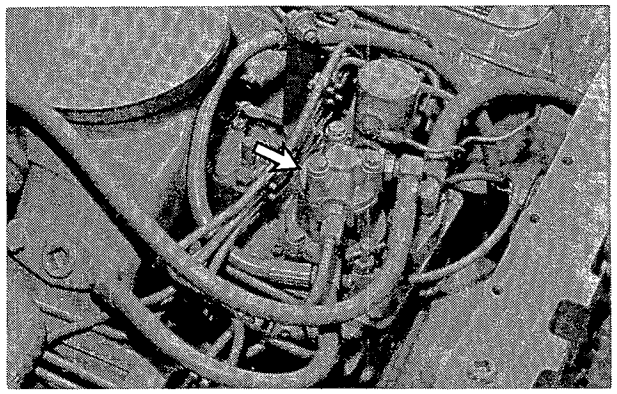
20. Install the valve covers. Tighten the bolts in the sequence shown, to 14 ± 3 N·m (10 ± 2 lb ft).

21. Connect the hoses to the crankcase ventilation valves or the crankcase breather (If L.E.S. equipped) and tighten the hose clamps to 2.3 ± 0.2 N·m (20 ± 2 lb in).

22. Start the engine and check for oil leaks. Stop the engine.

Air-Fuel Ratio Control (Turbocharged Engines Only)

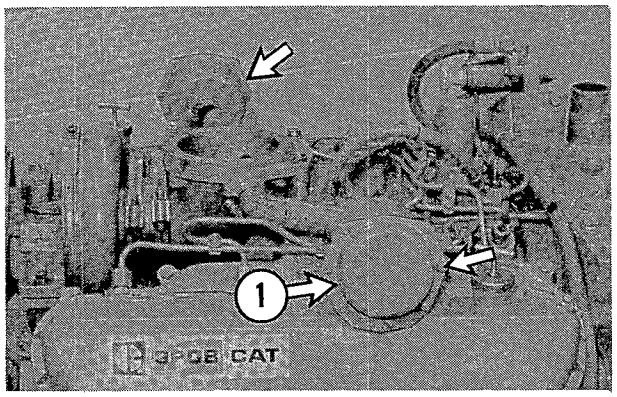
Check — Adjust



Slow engine response and low power may indicate a need for adjustment or repair. Your authorized dealers are equipped with the necessary tools, personnel and procedures to perform this service.

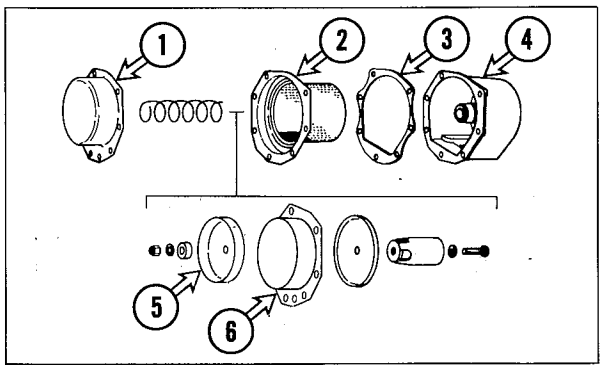
PCV Valve (If Equipped)

Replace Diaphragms



1. Clean the outside of the PCV valve(s) and the area around it. Inspect PCV hoses for deterioration or damage, replace if necessary.

2. Remove the screws and washers that hold cover ① in place.



3. Remove cover ① and the spring.

4. Remove the diaphragm assembly, inner sleeve ② and gasket ③ from housing ④.

5. Disassemble the diaphragm assembly.

6. Clean and inspect all parts. Replace any part that is worn or damaged. Always install a new gasket and diaphragm when the PCV valve is disassembled.

7. Assemble the diaphragm assembly using a new diaphragm ⑥.

8. To prevent diaphragm ⑥ from distorting and tearing during assembly, coat both flange sides of the diaphragm with gasket cement. Install it with the face marked "piston face" facing piston ⑤.

9. Coat new gasket ③ with gasket cement and install it against the rear face of inner sleeve ②.

10. Install the diaphragm assembly in housing ④.

11. Install the spring and cover ① with the washers and screws that hold cover ① in place.

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Thermostats

Check — Replace If Necessary

⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure.

Steam can cause personal injury.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to touch with your bare hand.

Remove the filler cap slowly to relieve pressure.

Cooling system conditioner contains alkali. Avoid contact with the skin and eyes to prevent personal injury.

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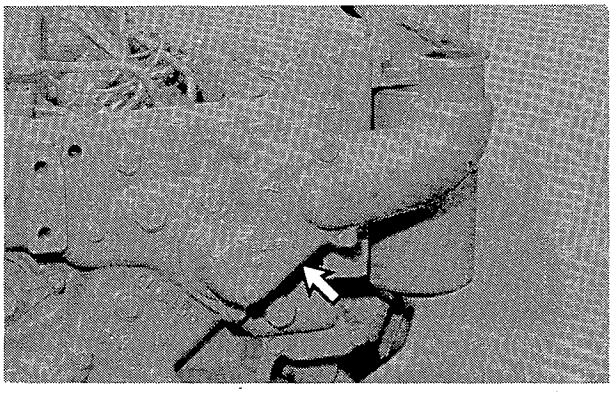
1. Loosen the radiator cap slowly to relieve any pressure and remove the cap.

2. Drain the coolant from the cooling system to a level below the thermostat housing.

3. Loosen the hose clamps and remove the radiator hose from the thermostat housing.

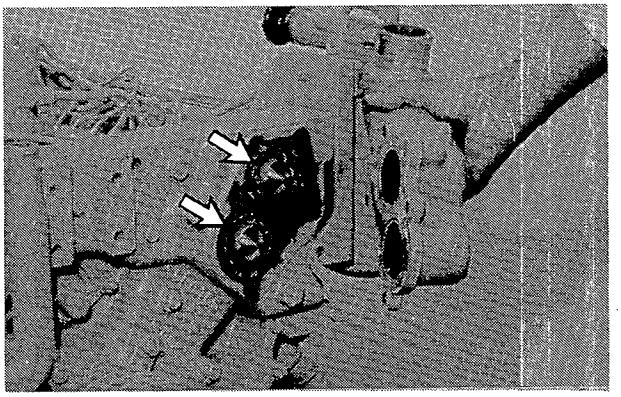


4. Remove the thermostat housing from the engine block.

5. Remove the thermostats and gasket from the engine block.

6. Replace thermostats and gasket.

NOTE: The thermostats should begin opening (bench test in atmospheric pressure) at approximately 80°C to 84°C (176°F to 183°F). The thermostats should be fully open at approximately 90°C to 94°C (194°F to 201°F).



7. Install the thermostats in the engine block.

NOTE: Former thermostats may be reused, if they meet test specifications above and are not damaged or have excessive buildup of deposits.

8. Install a new gasket and the thermostat housing on the engine block.

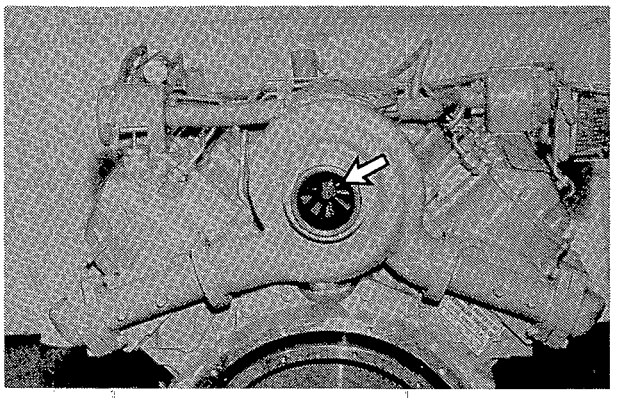
9. Install the radiator hose and tighten the hose clamps.

10. Add coolant to the cooling system to bring it to the proper level.

11. Start the engine and inspect for leaks and proper operating temperature.

Turbocharger (If Equipped)

Check



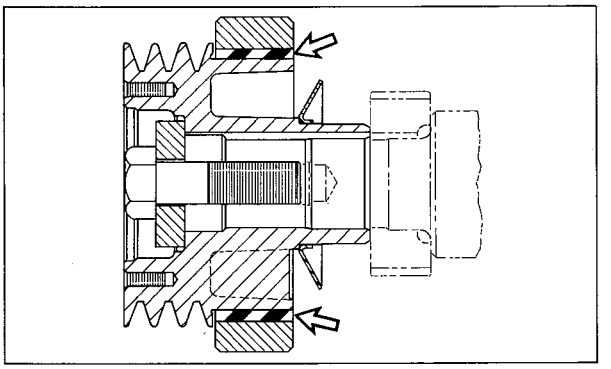
1. Remove the exhaust outlet piping from the turbocharger.

2. Turn the turbine and compressor wheel by hand. The assembly should turn freely.

3. If the assembly does not turn freely, refer to the Service Manual or consult your Caterpillar dealer.

Vibration Damper

Check



1. Inspect for separation of the rubber ring, between the inner hub and the outer flywheel ring.

2. Replace the vibration damper if there is separation or damage to the rubber ring.

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Coolant and PCV Hoses

Replace

⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure.

Steam can cause personal injury.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to touch with your bare hand.

Remove the filler cap slowly to relieve pressure.

Cooling system conditioner contains alkali. Avoid contact with the skin and eyes to prevent personal injury.

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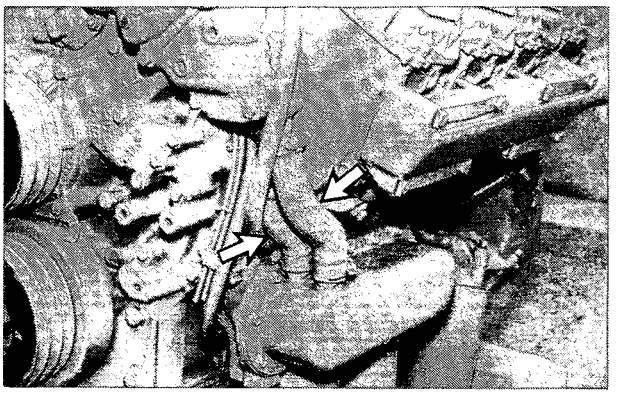
1. Loosen the radiator cap slowly to relieve any pressure and remove the cap.

2. Drain the coolant from the cooling system to a level below the oil cooler.

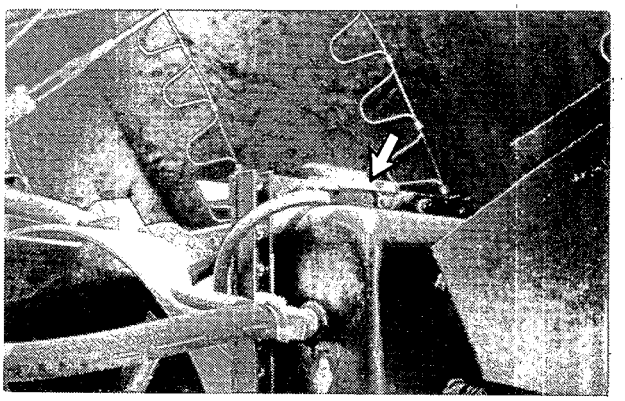


3. Loosen the hose clamps and remove the oil cooler hoses and discard.

4. Loosen the hose clamps and remove the hoses from PCV valves (if equipped) on both sides of the engine.

5. Install all new coolant and PCV hoses and tighten the clamps.

6. Add the coolant to the cooling system.



7. Start and run the engine with the radiator cap off. Allow the coolant to warm and stabilize.

8. Add coolant if necessary to bring the coolant to the correct level. Install the radiator cap.

9. Check for coolant leaks at the oil cooler connections. Stop the engine.

Cooling System

Clean, Refill and Add Conditioner Precharge

⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure.

Steam can cause personal injury.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to touch with your bare hand.

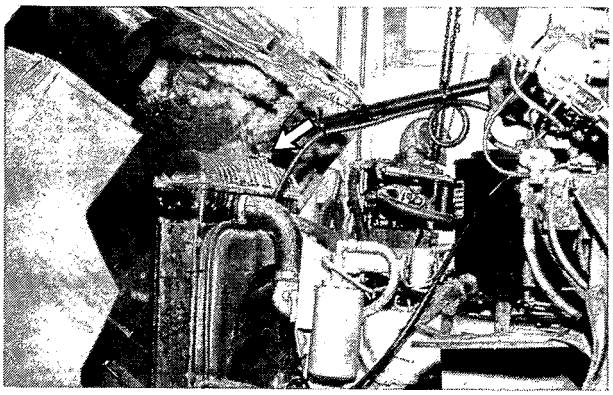
Remove the filler cap slowly to relieve pressure.

Cooling system conditioner contains alkali. Avoid contact with the skin and eyes to prevent personal injury.

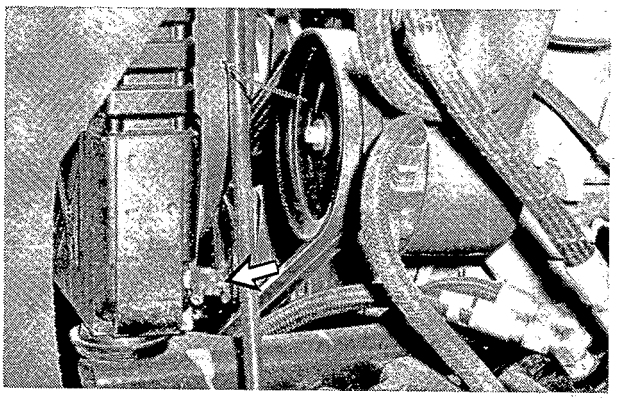
NOTICE

If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest expected outside temperature or drained completely to prevent damage.

Do not use Caterpillar cooling system conditioner or coolant conditioner elements with Dowtherm 209 Full-Fill coolant. Follow recommendations provided with Dowtherm 209 Full-Fill coolant.



1. Loosen the radiator cap slowly to relieve any pressure and remove the cap.



2. Remove the cooling system drain plugs or open the drain valve and allow the coolant to drain.

3. Install the drain plugs or close the drain valve.

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4. Fill the cooling system with a cleaning solution. Use a commercially available cleaner or 1 kg (2 lb) sodium bisulphate per 40 liters (10 U.S. gallons) water.

5. Start and run the engine 1/2 hour. Stop the engine and drain the cleaning solution.

6. Flush the system, with engine stopped, with water until the draining water is clear.

7. Install or close the drain valve. Fill the system with a commercially available neutralizer or 250 g (1/2 lb) sodium carbonate per 40 liters (10 U. S. gallons) water.

8. Start the engine and run it for 10 minutes. Stop the engine and drain the neutralizing solution.

9. Flush the system with clean water until draining water is clear.

10. Mix a solution of acceptable water, antifreeze and cooling system conditioner or if equipped with a coolant conditioner element, install a precharge element. Add 0.95 liters (1 quart) of Caterpillar cooling system conditioner per 30 liters (8 U.S. gallons) of cooling system capacity (for a 3% to 6% concentration).

NOTICE

If the engine is equipped with a Caterpillar coolant conditioner element, to prevent over inhibiting do not use both the liquid cooling system conditioner and the coolant conditioner element at the same time.

11. Fill the cooling system with the coolant solution at 20 liters (5 U.S. gallons) per minute or less to avoid air locks.

12. Start and run the engine with the radiator cap removed. Allow the coolant to warm and the level to stabilize.

13. Add coolant if necessary to bring the coolant level to the bottom of the fill pipe or to the correct level on the sight glass.

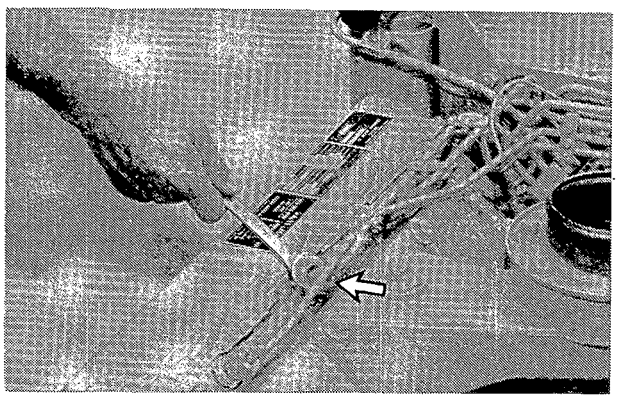
14. Check the condition of the radiator cap gasket. Replace it if damaged. Install the radiator cap.

Fuel Injection Nozzles

Test — Replace If Necessary

Whenever the engine performs in such a manner that a fuel injection nozzle is suspected of causing irregular running, smoking or knocking, isolate each fuel injection nozzle, one at a time, to determine the malfunctioning nozzle.

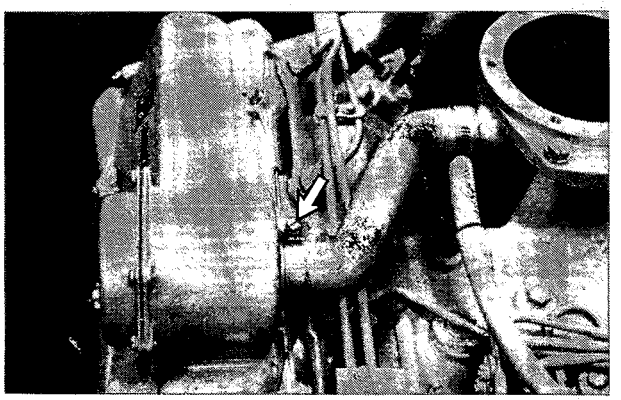
NOTE: For complete fuel injection nozzle testing and cleaning, consult your authorized Caterpillar engine dealer.



1. Loosen the fuel injection line nut at the cylinder head, one at a time, with the engine running. Be sure to tighten each fuel line nut after the test, before the next fuel line nut is loosened.

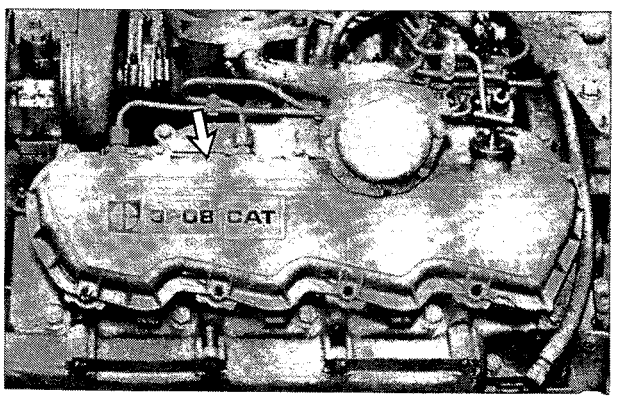
2. When a cylinder is found where the loosened fuel line nut does not make a difference in engine performance or smoking, have that cylinder injection nozzle tested.

To Remove Injection Nozzles



1. Clean the area around the valve cover.

2. Loosen the hose clamp and disconnect the hose from the PCV valve(s) or if low emission system equipped, disconnect the hose from the crankcase breather.



3. Remove the valve cover.

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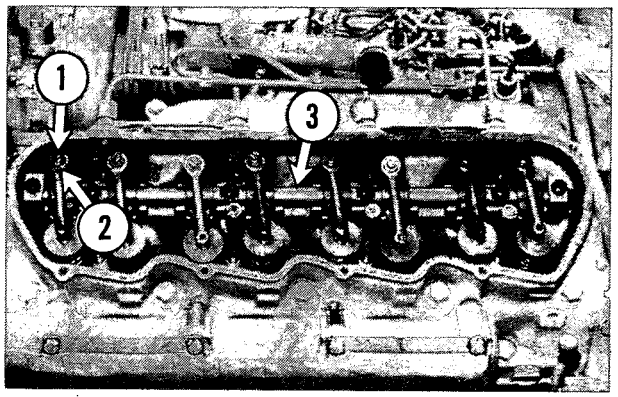
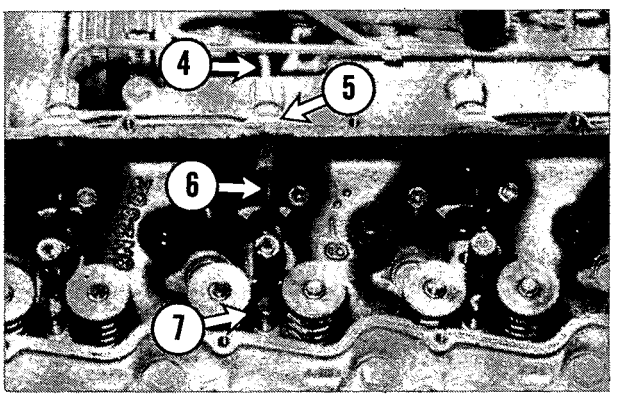


4. Loosen the valve adjusting screw locknuts ①. Turn adjusting screw ② counterclockwise until there is some clearance between the push rod end and the adjusting screw ②.

5. Remove rocker arm assembly ③.



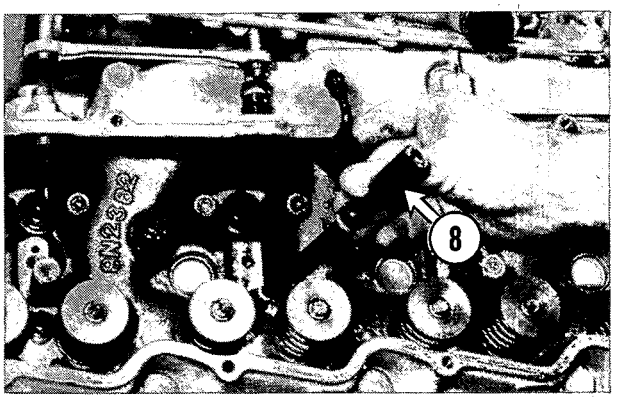
6. Thoroughly clean the area around each fuel line connection. Disconnect fuel line ④ from adapter ⑤.

7. Disconnect injection nozzle line ⑥ from adapter ⑤. Slide adapter ⑤ out of the cylinder head.

8. Remove clamp ⑦ and the spacer that holds the fuel injection nozzle in place.

NOTICE

Never use force to remove the fuel injection nozzles. Turn and pull the fuel injection nozzles straight out by hand. Never pry with a screwdriver or similar tool. Use 6V4061 Nozzle Pulling Group for difficult to remove nozzles.



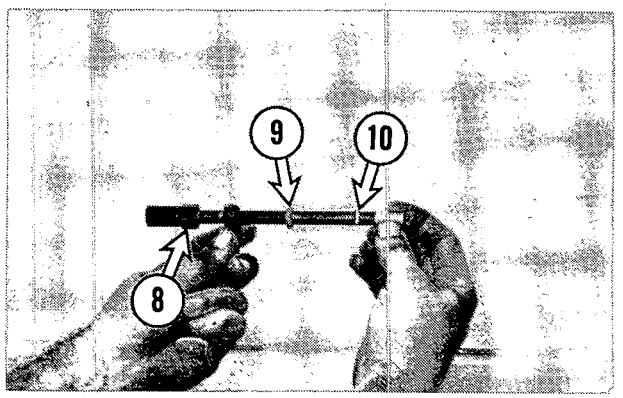
9. Remove fuel injection nozzles ⑧ from the cylinder head.

10. Have fuel injection nozzles ⑧ tested by an authorized Caterpillar engine dealer.

To Install Injection Nozzles

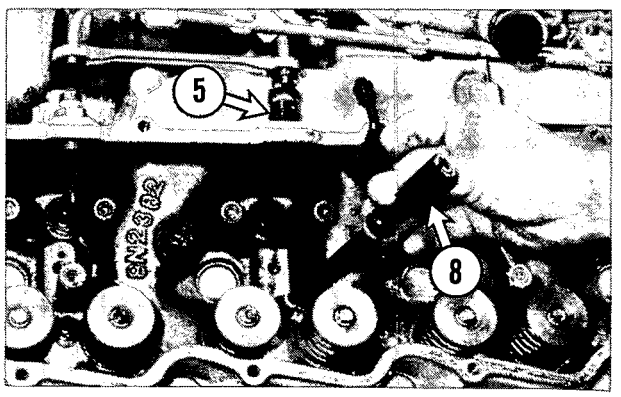
NOTICE

Never install an injector that has been dropped without first testing it. Examine the tip to be sure it is not broken or cracked. Using the Caterpillar 6V3020, 20X scope, provides a close examination of the nozzle tip and orifices.



1. Install a new compression seal (9) and carbon dam (10) on fuel injection nozzle (8).

2. Make sure the bore in the cylinder head and the fuel inlet fittings are clean.

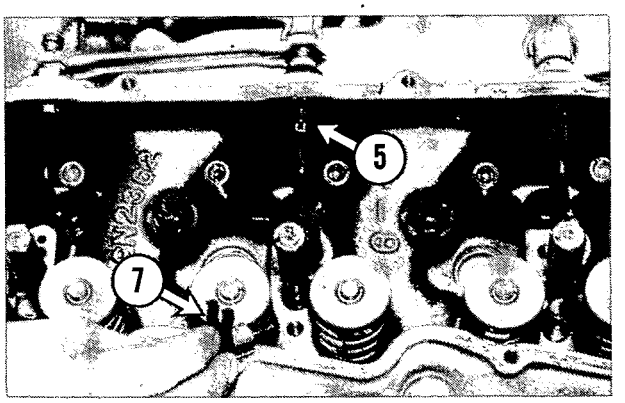


3. Install new O-ring seals on adapter (5) and fuel injection nozzle (8).

NOTICE

Do not bend the injector inlet line when installing injector into the cylinder head. Bending of the inlet line creates tension on the injector and can cause binding of the needle in the guide and can result in injector failure.

4. Install fuel injection nozzle (8) in the cylinder head. Turn and push the nozzle into its correct position. Never put lubricant on the nozzle or bore in the cylinder head.



5. Install adapter (5) in the cylinder head. Connect the nozzle and fuel injection lines to the adapter. Tighten the fuel line nuts to 40 ± 7 N·m (30 ± 5 lb ft).

6. Install the spacer and clamp (7) that hold the fuel injection nozzle in place.

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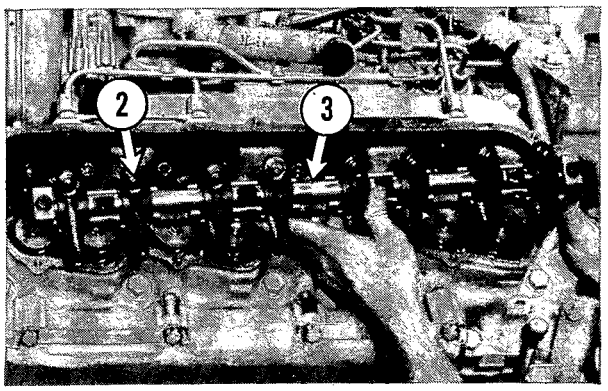

7. Put rocker arm assembly (3) into position. Make sure that valve adjusting screws (2) are loose and do not bind with the push rods during installation.

8. Tighten the rocker shaft mounting bolts to 24 ± 7 N·m (18 ± 5 lb ft).

9. Adjust the valves, see item "Engine Valve Lash."

10. Purge the fuel lines of air.

11. Start the engine and check for any fuel leaks. Stop the engine and correct any fuel leaks that may occur.

12. Install the valve cover and tighten the bolts in sequence to 14 ± 3 N·m (10 ± 2 lb ft).

13. Connect the hose to the PCV valve(s) or if low emission system equipped, connect the hose to the crankcase breather.

Governor

Check Full Load Speed (Set Point) and Low Idle RPM

NOTICE

These adjustments are to be made only by an authorized Caterpillar engine dealer or a mechanic that has the correct training.

Troubleshooting

On the following pages there is a list of possible problems. To correct a problem, make reference to the CAUSE and CORRECTION.

If problems are encountered, they should be corrected promptly to maintain engine operation.

This list of problems, causes, and corrections, will only give an indication of where a possible problem can be, and what repairs may be needed.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts.

This list can not give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs.

Troubleshooting Index

1. **Engine Will Not Start**
2. **Starting Motor Does Not Turn**
3. **Alternator Gives No Charge**
4. **Alternator Charge Rate Is Not Regular**
5. **Alternator Has Noise**
6. **Misfiring Or Running Rough**
7. **Low Power**
8. **Stall At Low RPM**
9. **Sudden Changes In RPM**
10. **Loud Combustion Noise**
11. **Valve Train Clicking Noise**
12. **Loud Valve Train Noise**
13. **Excessive Valve Lash**
14. **Little Or No Valve Clearance**
15. **Valve Spring Retainer Is Free**
16. **Noise In Engine**
17. **Excessive Vibration**
18. **Excessive White Smoke**
19. **Excessive Blue Smoke**
20. **Oil At The Exhaust**
21. **Too Much Lubrication Oil Used**
22. **Excessive Black Or Gray Smoke**
23. **Fuel Consumption Too High**
24. **Low Oil Pressure**
25. **Coolant In Oil**
26. **Oil In Cooling System**
27. **Coolant Is Too Hot**
28. **Engine Has Early Wear**
29. **Improper Operation Of The Low Emission System**
30. **Low Voltage To The Fuel Shutoff Solenoid**

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Troubleshooting

1. Engine Will Not Start

Cause	Correction
No Fuel to Engine	Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, fuel transfer pump failure, or plugged fuel filters.
Shutoff Solenoid Sticking	Solenoid must be energized to shut off engine. Actuate the control that operated the shutoff solenoid and listen for a clicking sound. If the clicking sound is not heard and the engine will not start, remove the solenoid. Lift the exposed lever and try again to start the engine. If the engine starts, the solenoid is bad. Replace the solenoid. Check the voltage supply.
Low Fuel Pressure	At cranking speed, the fuel transfer pump should supply fuel to the engine at 20 kPa (3 psi). If fuel pressure is less than 20 kPa (3 psi), replace the fuel filter. Check for air in fuel system, sticking, binding or defective fuel bypass valve. If pressure is still low, replace the fuel transfer pump.
Engine Improperly Timed	See your authorized dealer.

2. Starting Motor Does Not Turn

Cause	Correction
Low Output from Battery	Check battery. Charge or replace.
Defective Wiring or Switch	Repair or replace.
Defective Solenoid	Replace.
Defective Starting Motor	Repair.
Starter Ground Strap	Check connections from starter ground strap to frame ground.

3. Alternator Gives No Charge

Cause	Correction
Drive Belt Loose	Adjust belt.
Open or High Resistance in Charging or Ground Return Circuit or Battery Connections	Inspect all cables and connections. Clean, retighten or replace defective parts.
Excessively Worn, Open or Defective Brushes	Replace brush assembly.*
Open Rotor Field Coil	Replace rotor assembly.*
Engine Ground Strap	Check connections from engine to frame ground strap. (Starter ground strap not a suitable replacement ground for engine to frame grounding.)

4. Alternator Charge Rate Is Not Regular

Cause	Correction
Drive Belt Loose	Adjust belt.
Intermittent or High Resistance in Charging or Ground Return Circuits or Battery Connections	Inspect all cables and connections. Clean, retighten or replace defective parts.
Excessively Worn, Sticky or Defective Brushes	Replace brush assembly.*
Faulty Regulator	Replace regulator.*
Shorted or Open Rectifier Diodes	Replace defective rectifier diode assembly in alternator.*
Grounded or Shorted Rotor	Replace rotor assembly.*
Engine Ground Strap	Check connections from engine to frame ground strap. (Starter ground strap not a suitable replacement ground for engine to frame grounding.)

5. Alternator Has Noise

Cause	Correction
Defective Drive Belt	Replace belt.
Misaligned Belt or Pulley	Align drive pulley and alternator pulley and belt.
Loose Pulley	Tighten pulley nut. If keyway is worn, install a new pulley.
Worn bearings	Replace bearings.
Shorted Rectifiers in Alternator	Replace diode assembly.*
Armature or Rotor Shaft Bent	Replace components.*

6. Misfiring Or Running Rough

Cause	Correction
Defective fuel injection nozzle or fuel pump	Run the engine at the speed where it runs rough. Momentarily loosen the fuel line nut at the cylinder head to stop fuel supply to that cylinder. Check each cylinder in this manner. If a cylinder is found where loosening of the nut makes no difference in roughness, that nozzle and pump only need be tested.
Improper Valve Lash	Set to specified clearance.
Incorrect Fuel Injection Timing	See your authorized dealer.
Low Fuel Supply Pressure	Check fuel supply line for leaks or kinks, air in fuel system, sticking, binding or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump should supply fuel at 140 to 205 kPa (20 to 30 psi) to the engine when the engine is fully loaded.
Broken or Leaking High Pressure Fuel Line	Replace the line.
Air in Fuel System	Find source of air entry and correct. Bleed the system.
Bent or Broken Push Rod	Replace push rod.

7. Low Power

Cause	Correction
Accelerator Linkage	Adjust to obtain sufficient travel. Replace if damaged, bent or if linkage is too short. When accelerator is pushed to the floor, the spring retained levers at the governor should separate for full governor travel.
Low Fuel Supply Pressure	Check fuel supply line for leaks or restrictions, air in fuel system, throttle shaft seal leaking, sticking, binding or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump should supply fuel at 140 to 205 kPa (20 to 30 psi) to the engine when the engine is fully loaded.
Bad Quality Fuel	Remove bad fuel from the tank and put a good grade of clean fuel in the fuel tank. Install new fuel filter element.
Fuel Nozzle Failure	Run the engine at the speed where the defect is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for only that cylinder need be tested.
Leaks in Air Induction System (Turbo Only)	Check inlet manifold pressure.
Air Cleaner Restriction	Check air cleaner for restriction.
Incorrect Fuel Injection Timing	See your authorized dealer.
Excessive or Insufficient Valve Lash	Set to specified clearance.
Air-Fuel Ratio Control (Turbo Only)	Check adjustment or rebuild.*

8. Stall At Low RPM

Cause	Correction
Idle Speed Too Low	See your authorized dealer.
Accelerator Linkage Return Spring Too Strong	Replace with lower rate return spring.

8. Stall At Low RPM (cont'd)

Cause	Correction
Low Fuel Supply Pressure	Check fuel supply line for leak or kinks, air in fuel system, sticking, binding or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump should supply fuel at 140 to 205 kPa (20 to 30 psi) to the engine when the engine is fully loaded.
High Parasitic Loads	Check for excessive loading due to auxiliary attachments.

9. Sudden Changes In RPM

Cause	Correction
Governor Component Problems	Look for damaged or broken springs, linkage or other components. Determine if the rack can be moved manually. If any damage is noted in any of these components, replace if necessary.*

10. Loud Combustion Noise

Cause	Correction
Air in Fuel System	Bleed air from system.
Defective or Leaking Fuel Injection Valve	Replace.
Defective Fuel Injection Pump Plunger and Barrel Assembly	Replace.*
Incorrect Fuel Injection Timing	See your authorized dealer.*

11. Valve Train Clicking Noise

Cause	Correction
Excessive Valve Lash	Set to specified clearance.
Broken Valve Spring(s)	Replace valve spring(s) and all other damaged components.*
Insufficient Lubrication	Check lubrication in valve compartment. Should be very wet at all speeds.

12. Loud Valve Train Noise

Cause	Correction
Broken Valve Spring(s) or Rocker Arm Shaft	Replace damaged parts.*
Broken Camshaft	Replace all damaged parts. Clean engine thoroughly.*
Broken or Severely Worn Valve Lifters	Replace camshaft and valve lifters. Check for sticking valves and bent valve stems. Set valve lash to specified clearance.*

13. Excessive Valve Lash

Cause	Correction
Severely Worn Cam Lobes	Check valve lash. Replace camshaft and followers. Clean engine thoroughly. Set valve lash to specified clearance.
Broken or Severely Worn Valve Lifters, Loose or Broken Rocker Arm Shaft or Retaining Bolts	Replace valve lifters. Check camshaft for wear. Check for sticking valves and bent valve stems. Replace damaged parts. Set valve lash to specified clearance.
Valve Tip Wear	Set valve lash to specified clearance. If wear is excessive, replace valve.
Moderate Valve Lifter Face Wear	Set valve lash to specified clearance. If wear is excessive, replace valve lifter.
Push Rod Wear	Set valve lash to specified clearnace. If wear is excessive, replace push rod.
Rocker Arm Anvil Wear	Set valve lash to specified clearance. If wear is excessive, replace rocker arm.
Insufficient Lubrication	Check lubrication in valve compartment. Should be very wet at all speeds.

14. Little Or No Valve Clearance

Cause	Correction
Worn Valve Seat or Face of Valve	Reconditioning of cylinder head is needed. Make adjustment of valve clearance.

15. Valve Spring Retainer Is Free

Cause	Correction
Broken Keepers	Extensive engine damage may result from dropped valve. Replace all damaged parts.*
Broken Valve Spring	Replace valve spring.*
Broken Valve	Replace valve and any other damaged parts.*

16. Noise In Engine

Cause	Correction
Air Compressor Rod or Piston Failure	Repair or replace air compressor as necessary.
Engine Connecting Rod Bearing Failure	Replace the bearing. Check the connecting rod and crankshaft. Replace if necessary.*
Damaged Timing Gear Train	Replace components as necessary.*

17. Excessive Vibration

Cause	Correction
Loose, Worn or Defective Engine or Transmission Mounts	Tighten all mounting bolts securely. Replace components as necessary.
Loose Pulley and Damper	Retighten.
Defective Damper or Pulley	Replace damper or pulley.
Misfiring	See ITEM 6.
Unbalanced Fan or Clutch Components	Check by loosening or removing fan belts and operating engine for "short duration" at affected speed range to see if vibration is still present. If not, replace fan assembly. Out of balance clutch components can also cause vibration.

18. Excessive White Smoke

Cause	Correction
Cold Weather	Normal for some white smoke on starting.
Air in Fuel System	Bleed fuel system. Check for air leaks on suction side of fuel system.

19. Excessive Blue Smoke

Cause	Correction
Valve Guides Worn	Recondition cylinder head assembly.*
Piston Rings Worn, Stuck or Broken	Replace.*
High Crankcase Oil Level	Avoid overfilling. Determine cause and drain excess oil.
Misfiring	See ITEM 6.
Fuel Injection Pump Timing Wrong	See your authorized dealer.

20. Oil At The Exhaust

Cause	Correction
Excessive Valve Guide Wear	Recondition cylinder head assembly.*
Excessive Lubricating Oil in Valve Compartment	Check rocker arm shaft and plugs to assure that they are in place.
Worn Piston Rings	Inspect and replace components as necessary.*

21. Too Much Lubrication Oil Used

Cause	Correction
Oil Leaks	Replace gaskets or seals and tighten all connections.
Excessive Oil to Intake	See ITEM 20.
Excessive Valve Guide Wear	See ITEM 20.

21. Too Much Lubrication Oil Used (cont'd)

Cause	Correction
Crankcase Oil Level Too High	Avoid overfilling. Determine cause and drain excess oil.
High Oil Temperature	Check oil cooler bypass valve. Replace if defective. Clean oil cooler core.
Worn Piston Rings	Replace components as necessary.*
Worn Piston Rings in Air Compressor	Repair or replace air compressor as necessary.*
Engine Overload	Engine operating with horsepower increased.
PCV Valve(s)	Inspect and repair as necessary.

22. Excessive Black Or Gray Smoke

Cause	Correction
Insufficient Combustion Air	Check air cleaner for restriction. Check inlet manifold pressure.
Fuel Nozzle Plugged or Leaking	Replace nozzle.
Incorrect Fuel Setting or Injection Timing	See your authorized dealer.
Low Emission System Malfunction	See your authorized dealer.
Turbocharger Failure	See your authorized dealer.
Air-Fuel Ratio Control (Turbo Only)	Check adjustment or rebuild.*

23. Fuel Consumption Too High

Cause	Correction
Fuel System Leaks	Large changes in fuel consumption may result. Internal leaks will probably be accompanied by low engine oil pressure and increased oil level in the engine oil sump. Replace leaking components.
Fuel and Combustion Knock	Small but measurable increases in fuel consumption may be the result of defective fuel nozzles, misfiring or factors contributing to loss of power. See ITEM 6 and ITEM 7.
Incorrect Fuel Setting or Injection Timing	See your authorized dealer.
Air-Fuel Ratio Control (Turbo Only)	Check adjustment or rebuild.*

24. Low Oil Pressure

Cause	Correction
Engine Oil Diluted With Fuel Oil	Check lip-type seals on fuel transfer pump drive shaft. Drain crankcase and refill with clean lubricant.
Defective Suction Bell	Replace.
Excessive Crankshaft Bearing Clearances	Replace bearings and/or crankshaft.* Check oil filter operation.
Excessive Timing Gear Bearing Clearances	Inspect bearings and replace components as necessary.
Excessive Rocker Arm Bore or Rocker Arm Shaft Wear	Check lubrication. Replace components as necessary.
Defective Oil Pump	Repair or replace.*
Defect in oil pressure gauge.	Install new gauge.
Oil Pump Relief Valve Stuck	Clean valve and housing. Replace if necessary.
Oil Filter Plugged	Install new oil filter.
Improper Oil Level, Possible Oil Aeration	Check oil for foaming and level.

25. Coolant In Oil

Cause	Correction
Cylinder Head Gasket Failure	Replace gasket. Maintain proper torque on cylinder head bolts.
Cracked or Defective Cylinder Head	Replace cylinder head.*
Crack or Defect in Cylinder Block	Install a new cylinder block.
Leak in Oil Cooler	Install a new core for the oil cooler. Drain crankcase and refill with clean lubricant. Install new oil filter element.
Defective Air Compressor Cylinder Head or Gasket	Replace cylinder head and/or gasket.

26. Oil In Cooling System

Cause	Correction
Plugged Water Pump Cavity Drain	Remove plug.
Failed Oil Cooler Core	Replace oil cooler core.
Failed Head Gasket	Replace head gasket.
Cracked Cylinder Head Top Deck	Replace cylinder head.

27. Coolant Is Too Hot

Cause	Correction
Engine Speed Low	Low horsepower causing lug and low fan speed.
Coolant Level Low	Determine cause. Replace leaking gaskets and hoses. Tighten connections. Add coolant.
Shutters Not Opening Properly or Shutter Operating Temperature Set Too High	Adjust as necessary.
Defective Water Thermostat or Temperature Gauge	Check thermostat for proper opening temperature and correct installation. Check temperature gauge. Replace if necessary.

27. Coolant Is Too Hot (cont'd)

Cause	Correction
Incorrect Water Piping Connections From Engine to Truck Radiator	Check shunt line (if equipped) and vent line for correct installation.
Air Flow Through Radiator Restricted	Remove all debris from outer surface of radiator.
Combustion Gases in Coolant	Determine point at which gases enter the system. Repair or replace components as necessary.
Defective Water Pump	Check water pump impeller. Repair water pump as necessary.
Radiator Too Small for Engine Application	Install correct size radiator.
Fan Improperly Positioned in Shroud or Not Shrouded	Position fan correctly.*

28. Engine Has Early Wear

Cause	Correction
Intake Piping Failure (Air Cleaner)	Inspect all gaskets and piping for leaks. Repair all leaks.
Excessive Fuel Dilution of Lubricating Oil	Replace leaking components. This will probably be accompanied by high fuel consumption and low engine oil pressure.
Dirt in Lubricating Oil	Locate and correct source of dirt entry. Change lubricating oil. Change oil filter.
High Sulfur Fuel	The percentage of sulfur in the fuel will affect the engine oil recommendations. If the fuel has over 0.5% sulfur content, the CD/SE or CD/SF engine oil must have a TBN of 20 times the percentage of fuel sulfur (TBN as measured by the ASTM D-2896 method). Your oil supplier should be able to furnish the correct oils.

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29. Improper Operation Of The Low Emission System

Cause	Correction
Extended Oil Change Periods	Change oil at the correct intervals.
Switches Are Out of Adjustment	Adjust the switches. Inspect the load stop pin for wear.
Plugged or Restricted Precleaner and/or Air Cleaner Elements	Remove restriction or clean precleaner and/or replace air cleaner elements with new ones.

30. Low Voltage To The Fuel Shutoff Solenoid

Cause	Correction
A Defective Battery or Battery Not Fully Charged	Recharge low battery or replace defective ones.
Defective Battery Cables and/or Connectors	Replace defective battery cables and/or connectors.
Improperly Adjusted Voltage Regulator and/or Alternator	Adjust voltage regulator and/or alternator.
Incorrectly Constructed Wiring Harness With Resistance Wires	Replace wiring harness.
The Wiring Harness Was Not Assembled Properly	Replace wiring harness.

NOTE: A minimum of 12 volts must be supplied to the fuel shutoff solenoid, with the engine running, to ensure correct operation of the Low Emission System.

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these services.

Emission Related Components

Required Maintenance and Warranty Information

Information in this section does not apply outside the United States of America

Foreword

The United States Environmental Protection Agency has issued regulations to establish emission standards and ensure that new motor vehicle engines will perform within prescribed limits. These regulations require new motor vehicle and new motor vehicle engine manufacturers to furnish maintenance instructions necessary to ensure the proper functioning of the engine within these limits. The Operation and Maintenance Guide has been prepared for this purpose.

Maintenance, replacement or repair of the emission control devices and systems may be performed by any automotive repair establishment or individual using any automotive part which has been certified pursuant to EPA regulations.

Authorized dealers are recommended for major maintenance and repair work as they are staffed with trained servicemen, proper tools and are aware of the latest service methods and procedures. Owners and others who desire to perform their own work should purchase a Service Manual and obtain current information from their Caterpillar dealer.

Emission Control

The combustion process of a diesel engine produces exhaust byproducts such as smoke (visible), hydrocarbons and oxides of nitrogen (invisible). The dark smoke emitted by a diesel engine is soot or carbon particles and even in low concentration makes the diesel exhaust highly visible and offensive to most people. Every effort must be made to eliminate smoke through proper maintenance and operation.

Under certain conditions oxides of nitrogen react with certain hydrocarbons to form smog which can become irritating and toxic if large concentrations accumulate. Concentrations of this pollutant combined with pollution of other sources all contribute to the total air quality problem.

As an engine manufacturer, our goal is to see that environmental standards are met with a minimum additional complexity or cost to the product. Throughout the years, continuing research and design improvements have been directed at minimizing exhaust emissions. Caterpillar has incorporated items such as —

TURBOCHARGING: Reduces exhaust noise and provides more air per cylinder allowing the fuel to burn more efficiently. These engines are integrally designed for turbocharging.

RECOMMEND FUELS, LUBRICATING OILS AND MAINTENANCE SCHEDULES: To assure minimum exhaust emissions.

Maintenance Recommendations

Caterpillar truck engines are certified by the United States Environmental Protection Agency to comply with smoke and gaseous emission standards prescribed by Federal laws at the time of manufacturer.

Efficiency of emission control and good engine performance depend on adherence to proper operation and maintenance recommendations, use of recommended fuels and lubricating oils. It is recommended that major adjustments and repair be entrusted to your authorized dealer.

Emission Related Components

Various chemical fuel additives are commercially available that claim to reduce visible smoke. Although additives have been used by individuals to solve some isolated smoke problems in the field, they are not recommended for general use. Federal smoke regulations require the certification of engines without a smoke depressant.

The corrective steps taken immediately on discovery of worn parts, which may affect emission levels, will help assure proper operation of emission control systems. The use of genuine Caterpillar parts is recommended. Suppliers of non-Caterpillar parts must assure the user that the use of such parts will not adversely affect emission levels.

Regular service intervals, along with special emphasis on the following items, are necessary to keep exhaust emissions within acceptable limits for the useful life of the engine. Refer to the Maintenance Section of this guide for details and maintenance schedule. If the engine is operating under severe conditions, adjust maintenance schedule accordingly. See your authorized Caterpillar dealer to help analyze your specific maintenance schedule.

The following is an explanation of emission related component maintenance. See the Lubrication and Maintenance Chaft for the specific service interval for the following items.

LOW EMISSION SYSTEM: Check for correct operation at every oil change.

FUEL INJECTION NOZZLES: Defective fuel nozzles will normally cause the engine to misfire, run rough and smoke. Test and replace if necessary as recommended in the Lubrication and Maintenance Chart. Fuel nozzles can be tested by an authorized Caterpillar engine dealer.

AIR-FUEL RATIO CONTROL: The air-fuel ratio control is a device to control the smoke emission of an engine during its operation when low inlet manifold pressure exists.

POSITIVE CRANKCASE VENTILATION VALVE: Check and replace, if necessary, the diaphragm(s) in the PCV valves. The positive crankcase ventilation valve vents crankcase fumes back into the engine through the intake.

TURBOCHARGER: Check for any unusual sound or vibration in the turbocharger. Inspect inlet and exhaust piping and connections. Check bearing condition and repair or replace as necessary.

Supplemental California Emission Warranty

Effective with engines delivered to the initial user on or after January 1, 1980.

Caterpillar warrants to the initial user and each subsequent user of diesel truck engines (powering on-highway trucks) that such engines sold by it for installation in vehicles to be registered in the State of California conform at the time of sale with regulations of the California Air Resources Board applicable at time of manufacture for the time periods and subject to the terms and conditions of the Caterpillar Warranty for Emission Related Components, Form FEG02590, set forth below. This supplemental warranty covers the following parts:

Air-fuel Ratio Control - diaphragm, valve
Fuel Injection System - injector, camshaft and followers, timing advance
Intake Manifold
PCV Valve and Oil Filler Cap
Exhaust Gas Recirculation (EGR) Valve Body
Low Emission Control System
Turbocharger - compressor or turbine wheel rub or burst

During the term of this supplemental warranty, Caterpillar will provide, through a Caterpillar dealer or other establishment authorized by it, diagnostic labor that leads to the determination that a Caterpillar engine emission part is defective and will repair or replace at its option all other engine components damaged as a result of the failure of such defective engine emission part. User is encouraged to keep adequate maintenance records but the absence of such, in and of itself, will not invalidate this warranty.

The vehicle owner may obtain routine maintenance, repairs, and other nonwarranty work at any repair facility, or may perform the work himself. Such nonwarranty work need not be performed at a designated warranty station in order for the warranty to remain in force.

Emission Related Components

For information regarding an authorized service facility, call toll free 800-447-4986. If an authorized service facility is not available in the event of an emergency, warranty service may be performed by an individual or automotive repair establishment. Caterpillar will reimburse the user for the cost of such service as is covered under this supplemental warranty up to an amount equal to Caterpillar's suggested list price for parts used and labor charged based on Caterpillar's recommended time allowance for the warranty repair at the customary hourly labor rate in that geographic area. As a condition of reimbursement, replaced parts and receipted invoices must be presented at a place of business of a Caterpillar dealer or other establishment authorized by Caterpillar.

Customer Assistance

Caterpillar wishes to ensure that the Emission Control Systems warranty is properly administered. In the event that you do not receive the warranty service to which you believe you are entitled under the Emission Control Systems Warranty, call or write:

Caterpillar Tractor Co.
Manager, Truck Engine Business.
Peoria, Illinois 61629
(309) 578-6288

Effective November 1, 1972

Caterpillar Warranty

EMISSION RELATED COMPONENTS

Caterpillar warrants to the initial user and each subsequent user of new Diesel Truck Engines (powering on-highway trucks), subject to the provisions set forth below, that the engine (1) was designed, built, and equipped so as to conform at the time of sale with United States Environmental Protection Agency regulations applicable at the time of manufacture, and (2) is free from defects in material and workmanship at the time of sale which will cause the engine to fail to conform with such regulations for five (5) years or 100,000 miles or 3000 hours of engine operation, whichever occurs first after delivery of the engine to the initial user.

Caterpillar will provide a new part or a repaired part, whichever Caterpillar elects, along with labor for the installation of such new or repaired parts, in place of any parts found upon its inspection to be defective in material or workmanship. All of the charges for such parts and labor, when provided during normal working hours at a place of business of a Caterpillar dealer or other establishment authorized by Caterpillar, will be paid by Caterpillar.

An engine failure shall not be considered to be caused by a defect in workmanship or materials when such failure occurs as the result of:

(a) Improper installation of the engine.
(b) The use of engines in applications which exceed the limits recommended by Caterpillar for the model engine involved.
(c) The use of attachments which are not approved by Caterpillar.
(d) Lack of proper maintenance or other operator abuse.

This warranty is in addition to Caterpillar's standard warranty applicable to the series of engine involved.

Remedies under this warranty are expressly limited to the provision and installation of parts, as specified above, and any claims for loss arising out of failure of the engine to operate for any period of time, or special, indirect or consequential damage, or other economic loss are expressly excluded.

The term "Caterpillar" as used herein means Caterpillar Tractor Co., or one of its subsidiaries, whichever last sold the truck engine involved.

FEG02590-01 (6-83)

Important Reference Numbers

Chassis Serial No. _____

Engine Model _____

Engine Serial No. _____

Fuel Filter No. _____

Lubrication Oil Filter Element No. _____

Auxiliary Oil Filter Element No. _____

Coolant Conditioner Element No.

Precharge _____

Maintenance _____

Air Cleaner Element No. _____

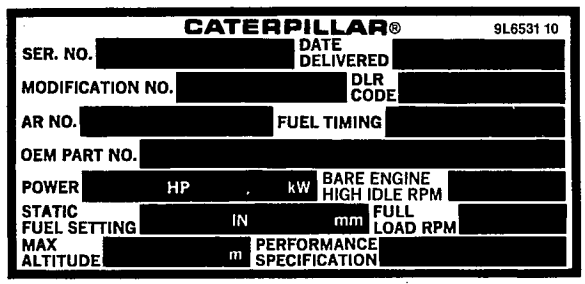
Power Steering Pump Belt No. _____

Fan Belt No. _____

Alternator Belt No. _____

When service is needed for your Caterpillar engine, be prepared to give the dealer all the information that is provided on the 9L6531 Information Plate located on the valve cover.

Discuss the problem with the dealer, such as; when it occurs, what happens, etc. This will help the dealer in troubleshooting and solving the problem faster.



Keep Maintenance Records

Keep records to show proof of compliance with the required maintenance practices and intervals.

The following types of documents are generally accepted as proof of maintenance or repair. All documents must show date, mileage, unit number, vehicle and/or engine serial number. If the vehicle is sold within the warranty period, transfer the records with the vehicle.

1. Dealer work order or itemized bill **3.** Owner's vehicle log MODEL_____

2. Owner's repair order **4.** Receipts SERIAL NO._____

SERVICE HOURS	MILES	kM	ITEM SERVICED	DATE

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Caterpillar Warranty

ENGINES USED TO POWER ON-HIGHWAY VEHICLES

This warranty applies to the following products delivered to the first user on or after April 1, 1980.

Caterpillar warrants new engines sold by it and used to power on-highway vehicles (except engines sold for use in the United States of America in personal or family pleasure vehicle applications, to which different warranties apply) to be free from defects in material and workmanship, subject to the following provisions.

Warranty Period

The base warranty period is 100,000 miles (160,000 kilometers), 3600 operating hours, or 24 months, whichever occurs first after date of delivery to the first user.

An extended warranty period also applies to the cylinder block, crankshaft and connecting rods in 3300 and 3400 Series Engines. These parts are warranted up to 300,000 miles (480,000 kilometers), 10,800 operating hours or 36 months, whichever occurs first after date of delivery to the first user.

Caterpillar Responsibilities

If a defect in material or workmanship is found during the warranty period, Caterpillar will provide at a Caterpillar dealer or other source approved by Caterpillar:

During the base warranty period:

- New or repaired parts at Caterpillar's choice.
- Labor needed to make the repair during normal working hours including reasonable labor to remove and reinstall the product if necessary, except that on 3200 Series Engines such labor will be provided as follows:

Period of Service				
Miles*	Kilometers*	Hours*	Months*	Labor
0-50,000	0-80,000	0-1800	24	100%
50,001-100,000	80,001-160,000	1801-3600	24	50%

*Whichever occurs first

- Usual and customary parts shipping charges to the approved source.
- Lubricating oil, filters, antifreeze and other service items made unusable by the warranty failure.

During the extended warranty period (3300 and 3400 Series Engines only):

- New or repaired (at Caterpillar's choice) cylinder block, crankshaft, and connecting rods damaged by a failure caused by a defect in one of these parts.

User Responsibilities

User is responsible for:

- Labor not provided by Caterpillar.
- Premium or overtime labor costs unless essential to prevent loss to perishable goods.
- Parts shipping charges in excess of those which are usual and customary.
- Costs for investigating performance complaints unless the problem is caused by a defect in Caterpillar material or workmanship.
- Giving timely notice of a warrantable failure and promptly making the product available for repair.

During the extended warranty period (3300 and 3400 Series Engines only):

- All costs except for the cylinder block, crankshaft or connecting rods as explained under CATERPILLAR RESPONSIBILITIES.

Limitations

Caterpillar is not responsible for failures resulting from:

- Any application or installation which Caterpillar judges improper.
- Attachments, accessory items and parts not sold or approved by Caterpillar.
- Abuse, neglect or improper repair.
- User's unreasonable delay in making product available after notice for product improvements authorized by Caterpillar.

This warranty is expressly in lieu of any other warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose, except Caterpillar emission related components warranties where applicable. Remedies under this warranty are limited to the provision of material and services, as specified above. Caterpillar is not responsible for incidental or consequential damages.

As used in this warranty the term "Caterpillar" means Caterpillar Tractor Co. or one of its subsidiaries whichever last sold the product involved.

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